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MINISTRY OF AGRICULTURE AND FISHERIES
DEPARTMENT OF AGRICULTURE FOR SCOTLAND, AND
MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND

REPORTS

on the work of

Agricultural Research Institutes

and on certain other agricultural investigations in the

United Kingdom

1931-1932

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This volume outlines the progress of agricultural research carried out with the aid of State funds during the Academic Year 1931–32 at Research Institutes and other centres in the United Kingdom. A numbered list of the papers published during the year by each Institute or research centre is appended to each report, and references to the numbers of these papers will be found in the text.

Those desiring further information regarding any subject dealt with in the reports should address their enquiries to the Director or other person concerned. A list of the names and addresses of Directors of Research Institutes and persons in charge of investigations at other centres is given in the Appendix (page 384).

Ministry of Agriculture and Fisheries,
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1933.

CONTENTS.

I.—RESEARCH INSTITUTE INVESTIGATIONS.

Page

A.—Soils, Plant Nutrition and Plant Physiology.

1. Rothamsted Experimental Station 9
2. Macaulay Institute for Soil Research, Aberdeen 23
3. Chemical (and Animal Nutrition) Division, Ministry of Agriculture for Northern Ireland 28
4. Research Institute of Plant Physiology, Imperial College of Science and Technology 28

B.—Plant Breeding, Crop Varieties and Seeds.

5. Plant Breeding Institute, Cambridge University 35
6. Welsh Plant Breeding Station, Aberystwyth 38
7. Scottish Society for Research in Plant Breeding, Edinburgh .. 46
8. Plant Breeding Division, Ministry of Agriculture for Northern Ireland 51
9. National Institute of Agricultural Botany, Cambridge 52
10. Plant Registration Station, Department of Agriculture for Scotland 57
11. Crop (and Animal Husbandry) Division, Ministry of Agriculture for Northern Ireland 58

C.—Horticulture and Glasshouse Crops.

12. Long Ashton Fruit Research Station, Bristol University .. 63
13. East Malling Research Station 85
14. Horticultural Research Station, Cambridge University .. 116
15. Experimental and Research Station, Cheshunt 125
16. John Innes Horticultural Institution, Merton 129

D.—Entomology and Plant Pathology.

17. Plant Pathological Laboratory, Ministry of Agriculture and Fisheries 135
18. Potato Virus Department, Plant Breeding Institute, Cambridge University 135
19. Biological Field Station, Imperial College of Science and Technology 138
20. Plant Pathological Laboratory, Department of Agriculture for Scotland 141
21. Seed Testing and Plant Diseases Division, Ministry of Agriculture for Northern Ireland 143

E.—Agricultural Parasitology.

22. Institute of Agricultural Parasitology, London School of Hygiene 151
23. Department of Helminthology, Department of Zoology, Edinburgh University 156

F.—Animal Pathology.

24. Research Institute in Animal Pathology, Royal Veterinary College, London 161
25. Institute of Animal Pathology, Cambridge University .. 163
26. Veterinary Laboratory, Ministry of Agriculture and Fisheries 169
27. Animal Diseases Research Association of Scotland, Edinburgh 173
28. Animal Diseases Division, Ministry of Agriculture for Northern Ireland 176

Page

G.—Animal Nutrition and Breeding.

29. Animal Nutrition Institute, Cambridge University 179
30. Rowett Research Institute, Aberdeen 186
31. (Chemical and) Animal Nutrition Division, Ministry of Agriculture for Northern Ireland 191
32. Pig Husbandry Experiment Stations : Harper Adams Agricultural College and South Eastern Agricultural College .. 193
33. National Poultry Institute—
    (*a*) National Institute of Poultry Husbandry, Harper Adams Agricultural College 195
    (*b*) Northern Breeding Station, Cheshire School of Agriculture, Reaseheath 197
    (*c*) Southern Table Poultry Station, South Eastern Agricultural College, Wye 198
34. Small Animal Breeding Research Institute, Cambridge University 198
35. Institute of Animal Genetics, Edinburgh University 199
36. (Crop and) Animal Husbandry Division, Ministry of Agriculture for Northern Ireland 208

H.—Dairying.

37. National Institute for Research in Dairying, Reading 213
38. Hannah Dairy Research Institute, Ayr 227
39. Dairy Bacteriology Division, Ministry of Agriculture for Northern Ireland 230

I.—Agricultural Economics.

40. Agricultural Economics Research Institute, Oxford University 233
41. Farm Economics Department, Department of Agriculture for Scotland 235

J.—Preservation and Transport.

42*. Low Temperature Research Station and Ditton Laboratory, Department of Scientific and Industrial Research and Cambridge University 239
43. Fruit and Vegetable Preservation Research Station, Bristol University 241

K.—Agricultural Engineering.

44. Institute of Agricultural Engineering, Oxford University .. 247

II.—LOCAL INVESTIGATIONS AT ADVISORY CENTRES.

L.— 45– 59. Chemistry 255
M.— 60– 75. Entomology 273
N.— 76– 91. Mycology and Botany 293
O.— 92–102. Veterinary Science 313
P.—103–115. Agricultural and Dairy Bacteriology 325
Q.—116–129. Economics 343
R.—130. Grassland 359

III.—OTHER INVESTIGATIONS.

131. Improved management of grassland 361
132. Production of seed potatoes in North Wales 363

* Included by the courtesy of the Department of Scientific and Industrial Research.

		Page
133.	Methods of mechanical analysis of soils	364
134.	Stubble cleaning	364
135.	*Spartina Townsendii*	365
136.	Bacterial diseases of plants	367
137.	Fluctuations in number of wild rodents	367
138.	Breeding seasons of field mice	368
139.	Economic ornithology	369
140.	Grey Squirrels	371
141.	Trials of hardy fruits for commercial purposes	371
142.	Plant breeding work on broccoli	372
143.	Efficacy of chlorates as weed-killers	373
144.	Bracken investigation	374
145.	Bacterial flora in cows' milk	374
146.	Stringhalt, shivering, etc., in the horse	375
147.	Influence of feeding on the blood and milk of dairy cows	376
148.	Statistical examination regarding variations in the composition of milk	377
149.	Worm infestation in sheep	377
APPENDIX.	List of Directors of Research Institutes and Heads of Advisory Centres	380
Subject Index		384

I.

RESEARCH INSTITUTE INVESTIGATIONS.

A.

SOILS, PLANT NUTRITION and PLANT PHYSIOLOGY.

1. ROTHAMSTED EXPERIMENTAL STATION.

The Soil.

Fertility and infertility of soil.—Much work is being done on the changes in the organic matter in the soil or added as farmyard manure or green manure. At Woburn one-third of the original stock of carbon (1.5 per cent.) and of nitrogen (0.15 per cent.) has been lost during 50 years of arable cultivation—an average annual loss of some 200 lb. carbon and 20 lb. nitrogen ; and this loss could not be diminished appreciably by any of the combinations of artificial manure given. Only when farmyard manure was given annually at the rate of about 6 to 8 tons per acre (the average is equivalent to 96 lb. N) was the loss stopped ; the organic matter of the soil then remained nearly constant. Of the nitrogen added in the farmyard manure about one-third was recovered in the crop, about one-third was found in the soil and the remainder was lost. Investigations on green manuring show similar losses of the organic matter added to the soil.

These results are of great practical importance because they indicate that on a light soil the " residual manurial values " for which the incoming tenant is required to pay compensation are, as calculated in the ordinary way, far above the benefit which the incoming tenant will ever receive. A new method of assessment is obviously needed.

On the heavier soil at Rothamsted the manure lasts much longer : losses are considerably less. Addition of farmyard manure not only maintains the soil stock of carbon and nitrogen, but even increases it. The usual method of assessment of residual values is less erroneous here than at Woburn.

One of the most potent factors in determining the loss of nitrogen is the leaching out of nitrate from the soil by rain in winter. The rate of loss depends on the crop that is ploughed under. Clover ploughed under in autumn rapidly gives rise to nitrates : rye grass much more slowly. Both crops add easily oxidisable carbon compounds to the soil, but clover adds, while rye grass removes, easily oxidisable nitrogen compounds. These results explain some of the discrepancies observed in green manuring practice, and point the way to a better use of this valuable, though at present unreliable, method of increasing soil fertility.

A new set of field experiments has been started to find the best way of maintaining fertility on " mechanised " farms where farmyard manure is not obtainable : in particular how best to return the straw to the land.

Basic slag.—During 1931-32, the Station arranged a series of field experiments on phosphatic fertilisers, with two sorts of slag,

and undertook the chemical analysis of the herbage and the statistical analysis of the full data. These are summarised in the Appendix to the Tenth Interim Report of the Permanent Committee on Basic Slag (36). In addition a detailed experiment was conducted in Hertfordshire on the effects of phosphatic fertilisers on the yield and composition of herbage of old grassland (1) mowed frequently and not grazed; (2) mowed twice per season with grazing at all periods except for about three weeks. This made it possible to compare the effects of the phosphatic fertilisers under conditions close to those of normal pasture. High responses were obtained from superphosphate and high soluble slag and low ones from mineral phosphate and low soluble slag. In a similar experiment on frequent mowing in Devon, mineral phosphate gave high responses. In general it may be said that low soluable slag gives poorer results than the more soluble fertilisers except perhaps in those very poor pastures in which the response to phosphatic fertilisers and the general improvement are so slow that the immediate value of the more soluble forms is lost.

Soil cultivation.—A new type of field experiment has been started in which cultivation methods and manures are combined in various ways so as to discover the interaction between manuring and cultivation. The method is useful for costly crops like potatoes and sugar beet: it was shown, for example, that the ploughing under of dung immediately it was applied gave 14 cwt. more of sugar beet roots and 34 cwt. more of tops per acre than ploughing under three weeks later.

Considerable attention is being paid to the meaning of soil tilth and the factors concerned in crumb structure. One of the important properties of the soil crumbs is their stability towards water: crumbs that will persist when moist are much more conducive to productiveness than crumbs which readily break down. Stability depends on the composition of the clay: it is greater for a calcium clay than for others: it is enhanced by micro-organic action, apparently through the formation of a film on the surface.

The properties of the clay, however, depend on the liquid with which it is moistened. The behaviour of clay in various organic liquids is being studied in detail and is yielding some remarkable regularities according as the liquid is polar or non-polar. This work is giving much information about the nature of clay and about the difference between one clay and another, *e.g.*, between the Rothamsted clays, the London clay, the lower Lias and others. The physical and chemical investigations on clay are gradually approaching completion, and some distinct advances may be expected in the near future.

The plant.—The new methods of field experiment designed in the Statistical Department and worked out on the Rothamsted

fields have been further developed and much work has been done on tests of significance. Large, complex field experiments are found to be considerably more efficient, so far as significance is concerned, than small simple ones. They are, however, more laborious and costly to carry out. Much work is being done on the principles of design and methods of increasing efficiency: the technical details are being studied in the field.

These new methods have already given much new information about fertilisers which has been embodied in a volume published in September, 1931, by the Ministry of Agriculture, entitled " Artificial Fertilisers " (3s. 6d. net). The first edition was rapidly exhausted, and a second edition has now been prepared.

Sugar beet.—All of the 1931 experimental crops at Rothamsted, Woburn and at a number of outside centres were sampled for analysis for dirt-tare and sugar content. The results showed that the effects of fertilisers and other treatments on sugar contents were small by comparison with their effects on yield and further that the irregularities in yields were much greater than those in sugar percentage. As in past seasons there was some tendency for nitrogenous fertilisers to reduce the sugar percentage, often by amounts which were statistically significant, but of little commercial importance. The detailed consideration of the results for yield of roots and their sugar percentages showed that the responses to nitrogenous fertiliser were less than are generally obtained with other root crops and raised the question whether some other factor of variety or cultivation was not limiting responses.

Hitherto it has been impossible to make any important investigation into the manuring and cultivation of sugar beet: last year, however, a scheme of combined variety, cultivation and manuring experiments was started in association with the National Institute of Agricultural Botany, which, if it can be continued, should show how to reduce considerably the cost per ton of roots.

Potatoes.—The field experiments on potatoes at various centres have been continued; data are being accumulated showing the effect of soil type and season in modifying the action of fertilisers on this crop.

The effect of manuring on quality has been studied: chlorides reduce the dry matter: potassium sulphate and sulphate of ammonia have no effect in this respect. Sulphate of ammonia increases the protein content and slightly reduces the quality. Potassic fertilisers slightly improve the quality: phosphates have no action. The quality tests were made by Dr. Lampitt, at Messrs. Lyons' laboratories.

Barley.—The work on barley is done in association with the Institute of Brewing.

The " quality " of barley is shown to be closely related to the nitrogen content and to the proportion of husk and other resistant

material in the grain. From a knowledge of these it is possible to calculate the yield of malt extract per ton of barley under standard malting conditions ; the calculated and observed values agree well and the method is now used on the large scale. Low nitrogen content of the grain is generally associated with high quality and the growers' aim should be to produce barleys of not more than about 1.55 per cent. of nitrogen (*a*). The necessary soil, manuring and cultural conditions have been worked out. Where the conditions provide a barley of less than this percentage of nitrogen the fertiliser dressing considerably improves the yield without raising the nitrogen content, *i.e.*, without detriment to quality, but where the nitrogen percentage exceeds 1.65 fertilisers may increase it still further.

The effect of weather conditions on yield and nitrogen content has been studied in the Statistical Department. Additional rainfall above the normal at Rothamsted and Woburn depresses the yield, but no simple connection can be traced. It is shown, however, that rain plays a more definite part in determining nitrogen content of the grain, and from a knowledge of rainfall figures to the end of June it has been possible to calculate the percentage of nitrogen in the grain that will be harvested four weeks later : the observed and the calculated figures agree well.

Wheat.—Some of the work in the Physics Department was seen to have close bearing on the properties of dough, and a simple method was devised for assessing the characters of the dough (" body " and others) of importance to bakers : this is being further examined (12).

Lucerne.—The sales of lucerne cultures have increased and each year constituted a new record till 1932, when there was a decline. The problems associated with the cultivation of the crop are also studied. It is noteworthy that the acreage of lucerne which was falling rapidly before the cultures were available, steadily increased till 1932.

The mechanism of infection is being steadily worked out and is proving to be of extraordinary interest.

The nodule organism occurs in a number of strains, some of which are much more efficient than others. They are not, however, permanent, and a given strain is liable to " dissociate " into new ones quite distinct from the original. The " dissociation " has been observed with one of the disease bacteria in the Plant Pathology Department : it necessitates constant watch on the cultures sent out to farmers, as some of the new forms might well prove to be relatively inefficient.

Work is now being pushed forward on the clover organism with a view to testing the possibility of cheaply improving poor pastures in hill regions and elsewhere.

(*a*) For beers which are not to be kept, higher nitrogen content is permissible.

Grass.—A considerable amount of work has been done on the establishment of new grassland and the management of established grass.

Broadly speaking, this has shown that the flora finally established depends on the soil conditions, the manuring, and the management, but only to a smaller degree on the seeding.

The seeding, however, plays a great part in determining the length of the time needed to establish the grass, and the profitableness of the first two or three years after laying down.

The effects of different seedings, systems of manuring, and management, on the character and composition of the herbage are studied in detail on some 160 acres of grassland, some of which is grazed and some hayed. In particular, it has been shown how a good pasture can be cheaply produced in three years on land usually regarded as capable only of bearing second class grass.

One important result of the investigations on the use of basic slag on grassland, carried out during the last ten years by the Rothamsted Staff under the ægis of the Basic Slag Committee of the Ministry of Agriculture, has been to show that the "low soluble" slag formerly sold in large quantities to farmers is generally much less effective than "high soluble" slag of the same phosphate content, though it may be useful on poor soils in wet districts. This work is done in association with the slag grinders, and it is satisfactory to note that the "high soluble" slag which in 1924-5 formed only 51.7 per cent. of the slag offered to farmers, has since 1928-9 formed 73 per cent.—a marked gain to farmers, seeing that nearly 1 million tons of slag has been bought by them during this period.

General Microbiology.

The proper work of the Microbiology and Fermentation Departments is the study of the micro-organisms in the soil, but a few years ago it reached a stage where practical applications were possible and since then most of the work has been turned in this direction, though the purely scientific investigations still continue (79, 80).

The applications are concerned with the biological decomposition of organic matter, the general course of which has now been discovered. Three applications are being tried :—

(i) *The decomposition of straw to produce a humic manure like farmyard manure.*—This has now developed so far that it is handed over to the Adco Syndicate who still, however, carry on their scientific work at Rothamsted. The process is very successful and many thousands of tons of manure are made each year with the materials supplied by the Syndicate. Market gardeners and horticulturists at home, and planters of many crops in tropical and sub-tropical countries, are specially interested.

(ii) *The purification of effluents from sugar beet factories.*—A biological oxidation has been worked out under the ægis of the

Department of Scientific and Industrial Research, and it has been developed to the semi-commercial scale at the Colwick Factory. It is proving quite satisfactory and has definitely shown that the discharge of unpurified effluents into rivers need not occur (78).

(iii) *The purification of effluents from milk factories.*—The work is proceeding on the same general lines as for the sugar beet effluents, but modifications are necessitated by the fat which is always present and which leads to clogging of the filters. Various methods are being tried to overcome this difficulty.

Plant Pathology.

Both Mycological and Entomological Departments lost their leaders last year: Dr. Imms proceeded to Cambridge as Head of the new Entomology Department, and Dr. Brierley to Reading as Professor of Agricultural Botany. This will lead to some reorienation of the work.

Bacterial and fungal diseases of plants.—During his twelve years' service at Rothamsted Dr. Brierley devoted much attention to the genetical analysis of the fungus *Botrytis* and isolated large numbers of races. He found that new strains might arise, but they could not be produced at will by varying the conditions; a strain could be temporarily altered by changed conditions, but it returned to its old characteristics with reversion to the old conditions.

Apparently-pure natural infections often consist of a mixed population of various races, but artificial infections give rise only to the original infecting race. All this work is now being written up for publication.

The laboratory testing of potatoes for susceptibility to wart disease has continued in conjunction with the Ormskirk Station, and further attempts have been made to discover why some varieties are resistant and others are not.

The study of the influence of environmental conditions on the angular leaf-spot or black-arm disease of cotton has been continued by Dr. R. H. Stoughton (63). The investigations, which have now been in progress for four years, are carried out by the use of six special chambers erected under the special grant from the Empire Marketing Board.

The work during the year has been directed to a study of the time factor in the influence of the environment, *i.e.*, the effects produced by changes of environment at various definite intervals of time. Broadly speaking, it may be said that the main factor in the action of air temperature is the mean value during the incubation period of the disease, a time which varies from about five to twelve days, according to this mean temperature. Temporary variations from a constant value appear to have little or no effect on the course of the disease, and large variations have effect only in so far as they appreciably alter the mean value.

The relative humidity, on the other hand, appears to be of importance only during the first 24-48 hours after inoculation by spraying. A high humidity at this time favours infection by allowing the infection droplets to persist long enough for the bacteria to enter the stomata. Once penetration of the tissues has occurred, subsequent alterations in humidity seem to have no effect.

The investigations are now being extended to include the influence of time of spraying with respect to the illumination-period, and the effect of different times of illumination.

Dr. Stoughton has also continued his study of the important parasite *Bacterium malvacearum*, which causes black-arm disease in cotton. Contrary to the general belief about bacteria, it has apparently a sexual stage characterised by the fusion of two cells and the formation of a fusion body or zygospore (62). Further, it exists in many different strains, and these may remain constant for a long time: then suddenly they may "dissociate" into new strains which either persist or reproduce the parent type. This dissociation cannot be controlled.

Virus diseases of plants.—

(i) *General Virus Studies.*

An attempt was made to determine by differential filtration the approximate size of the particles of certain selected viruses. For this purpose a series of collodion membranes of graduated porosity was prepared (61) by Dr. Donald MacClement, from Canada, who worked at the station from October, 1931-July, 1932. Clarified juice from infected plants was used as the material for filtration, and the pore sizes were determined which, on the one hand, just allowed the virus to pass, and, on the other, just prevented its passage. It was found that the plant viruses differ greatly in size from one another. The viruses of ordinary tobacco mosaic and of so-called yellow mosaic passed through pores of 0.051μ diameter; the virus of *aucuba* mosaic of tomato passed pores of 0.112μ, but not less diameter; the virus of a *Hyoscyamus* mosaic found by Dr. Hamilton passed 0.30μ, but not through any smaller pore. These figures indicate that the size of the particles of the virus is about 15$\mu\mu$ in the case of tobacco or yellow mosaic, about 40-50 $\mu\mu$ for *aucuba* mosaic, and 150$\mu\mu$ for the *Hyoscyamus* virus.

By use of these membranes it was possible to separate two viruses which occurred together, in nature, in the same plant. The virus *Hyoscyamus III* was found to be occasionally mixed with a second quite different virus; and it was possible to separate the two by filtration, as well as by heat, by the use of differential hosts and by other means (61). There was some suggestion that the second virus was arising spontaneously from the first, and this is being investigated.

(ii) *Virus Physiology.*

The study of the movement of the virus agent in the plant has now been largely completed, and it would appear that the agent travels freely from cell to cell along the protoplasmic strands after entry has been effected through a broken protoplast. The problem now in hand is the mechanism of movement as furnishing some information as to the nature of the agent.

Experiments with N. glutinosa (65).—A large series of experiments have been carried out with *N. glutinosa*, the leaves of which develop local necrotic lesions as a consequence of inoculation with *aucuba* mosaic juice. Dilution experiments have indicated that the virus agent is particulate in nature and that there is a definite relation between the number of necrotic spots and the dilution of the juice. As a consequence, it would appear that one virus agent was sufficient to cause one spot, especially in the light of the fact that the proportion exists between the number of spots and the amount of the inoculum and not with the area rubbed.

Further work has indicated that counts of the numbers of effective virus particles present in a juice may be made using this method of dilution.

The amount of multiplication of the virus agent in the leaf tissues of *N. glutinosa* has been compared with that in tomato leaves. The multiplication in tomato tissue is apparently many times greater than in the other.

The metabolism of the infected plant.—This work has been continued and expanded. The dry matter and the sugar content of the infected tissue is less than that of the normal, while the CO_2 output under some conditions is higher. The relationship of the CO_2 output in air, in oxygen, and in nitrogen to the carbohydrate content of the tissues has been studied to some extent and promises to furnish interesting data.

The spread of virus disease from weed plants.—Two weed plants commonly growing near tomato houses have been found to contain a virus communicable to tomato. Juice of nettles with a necrosis of the leaf tissues on inoculation into tomato gave rise to symptoms of " Streak," while the juice of a horseradish plant showing faint symptoms of mosaic on inoculation into tomato induced the formation of a well-marked mosaic in that host.

Many other possible hosts have been tried, but so far no disease has been communicable to tomato, even from some very likely specimens.

(iii) *Virus Cytology.*

The development of chloroplasts.— *Aucuba* mosaic produces a vivid yellow mottling on the leaves, and in the yellow areas chloroplasts are almost entirely wanting. This absence of chloroplasts was investigated in three solanaceous hosts, all of which gave

similar results. It is brought about by the inhibition by the virus of the development of the plastid primordia ; usually the primordia are destroyed. If plastid development is not prevented in a very early stage perfectly normal plastids are formed. Mature plastids are never affected by the virus, but occasionally intermediate stages may be.

Intracellular inclusion bodies.—The bodies due to infection with *aucuba* mosaic virus had been found to be built up by gradual aggregation of minute protein particles, which appear in the cytoplasm soon after infection. They could not be found in meristematic tissue. Incipient bodies appear after increase in cell size has commenced, and often not until plastid development is well advanced. Accordingly the inclusion bodies are formed indiscriminately in green and chlorotic areas, the virus having presumably reached the green tissue too late to inhibit plastid production (64).

Attempts have been made to induce in the cells of uninfected plants conditions comparable with those existing in virus disease ; and some very promising results have been obtained.

(iv) *Virus Entomology.*

Artificial feeding of aphids.—The methods previously devised for maintaining and culturing aphids apart from the living plant have been further developed and refined. As a food supply plant juices are unsatisfactory, because they rapidly become toxic, and the best substitute remains a weak solution of sugar in tap-water. Small pieces of vegetable epidermis, *e.g.*, of cabbage, have been found the most satisfactory membrane on which to place the insects and through which they reach the food-supply.

With this technique, further experiments have been made to determine the time required for the passage of ingested material to travel round the insect body and appear in the saliva. The absolute quantities involved are so small that satisfactory testing is difficult and uncertain, and the attempt has been made to use radio-active substances as test-material. The most promising results have been obtained by the use of a feeding solution containing polonium (Radium D) ; and the work has been carried on with the kind assistance of Dr. Chadwick, of the Cavendish Laboratory. Adequate control of environmental conditions is difficult, and further experiments are necessary before assured results can be given.

Hyoscyamus virus disease.—It has now been established that there are at least three distinct virus diseases attacking this commercial crop. None attacks potato, although one of them (*Hyoscyamus II*) resembles the Y component of potato crinkle in many particulars, *e.g.*, insect transmission, filterability, longevity,

symptoms, host-range apart from potato, and another (*Hyoscyamus IV*) resembles the other potato crinkle component X. The third disease (*Hyoscyamus III*) has been met with only once in the field, but it has remained stable for over two years in culture, and has characteristic properties and symptomatology. It resembles *Hyoscyamus II* in many respects, and it is possible that these two viruses are variants of the same pathogen. There is a pronounced seasonal variation in the infectivity of this virus (*Hyoscyamus III*), which is much less infectious in the autumn than in the spring, especially on insect transmission, and is much less severe in its effects at that season, and it is remarkable that in plants infected with this virus and also in plants infected with *Hyoscyamus II* there sporadically appears a fourth virus with perfectly distinct characters. The origin of this fourth virus is under investigation.

The work on virus diseases is being carried out with the aid of a grant from the Empire Marketing Board.

Insect pests.—Dr. C. B. Williams has commenced an investigation into the abundance and activity of insects with a view to correlation with climatic conditions. He is for the present working out methods of expressing " abundance " in some numerical form.

Dr. Barnes is continuing his studies of midges infesting willows (70), foxtail, wheat (68), and other plants. A large amount of advisory and identification work is done on this group of insects.

Insecticides.—Considerable advance has been made with the study of pyrethrum, one of the most useful insecticides available. At present large quantities are imported : experiments made in conjunction with the Staff of the Ministry of Agriculture's Plant Pathological Laboratory, Harpenden, show that the plant can, however, be grown satisfactorily in England ; it requires but little feeding and its cultivation would fit in with existing systems (74). Dr. Tattersfield's investigations have been concerned with the discovery of means of estimating the toxicity of different samples. One weakness of pyrethrum is that the toxicity of the fine powder (in which form it is often used) is lost on exposure to air, particularly in the presence of sunlight (75). This was traced to oxidation, and was much reduced by admixture with certain antioxidants. A dusting machine has been devised which appears suitable for the evaluation of contact insecticide dusts.

Work on Derris root and other rotenone-containing plants has been continued in conjunction with the Department of Agriculture of Malaya and British Guiana, where these plants grow : also with East Malling. The rotenone content is usually assumed to be an adequate measure of toxicity, but this is by no means certain, and the problem is being further examined. The matter is of great importance, because plants have been found richer in rotenone than the ordinary samples of Derris, notably a Peruvian plant Cubé, a species of Lonchocarpus.

At present experiments are being conducted at various centres at home and in the tropical parts of the Empire with Derris, but if the Cubé is a better insecticide it should obviously be tested.

Bee Research.

Some remarkably interesting results have been obtained by Mr. Morland in the study of the internal economy of the hive and the daily occupations of the bees. Each batch of bees introduced into the hive was marked so that its subsequent history could be followed. It is shown that the youngest bees attend to the brood : then later on in life they attend to the hive, cleaning and ventilating it : still later they go out foraging for nectar. So long as promotion is continuous the hive goes well, but if promotion ceases the attendants of the brood proceed to make queen cells and this soon leads to swarming.

The work on bees will be greatly advanced as soon as it is possible to study diseases, but this would necessitate an additional bacteriologist.

Titles of papers issued during the year.

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3. ———— : Soils and manures, *The Farmer's Guide to Agricultural, Research in* 1931. Roy. Ag. Soc. Eng., 1932.
4. ———— : Soil conditions and plant growth. 6th Edition, 1932.

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6. Keen, B. A., and Cashen, G. H. : Studies in soil cultivation. VI. The physical effect of sheep folding on the soil. *J. Agric. Sci.,* **22,** 126, 1932.
7. Cashen, G. H. : Measurements of the electrical capacity and conductivity of soil blocks. *Ibid,* **22,** 145, 1932.
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2. MACAULAY INSTITUTE FOR SOIL RESEARCH, ABERDEEN.

Development of the Institute.

Some progress has been made with the alterations and equipment of laboratories at Craigiebuckler, but the work has been delayed by the present financial conditions.

Advisory Work, etc.

A certain amount of advisory work on draining, liming and manuring has been carried out.

In the south-west of Scotland Mr. M. M. Monie has been experimenting with field drainage machines with a view to improving the cutting irons and the throw-off of the cut material. He has also been measuring on a range of soils the pull necessary to withdraw a soil auger designed by him, with a view to advising farmers which soils are suitable for mole draining. He has also continued his work on soil colours and is at present preparing an album of typical soils mounted in collodion which he considers can be used as colour standards.

Special Investigations.

Interpretation of tests for manurial requirements.—A series of 13 soils from different parts of Scotland and derived from widely different geological formations was selected as representing some of the main soil groups in the country. The manurial requirements of these soils have been determined by the Mitscherlich method, and the same determinations are now being carried out by various chemical methods. It is hoped in this way to obtain information which will assist in the interpretation of the results from chemical tests.

The effect of different phosphatic manures on various soil types.—Five of the soils used in the above investigation were employed and each received a dressing at the rate of 1 cwt. P_2O_5 per acre of the following manures: High grade basic slag, low grade basic slag, superphosphate, ground mineral phosphate.

Horn manure.—As considerable amounts of this manure are produced locally, pot and field trials have been carried out to compare

it with ammonium sulphate and sodium nitrate as a nitrogenous fertiliser. Most of the tests have been carried out on horticultural crops, and the results indicate that this material may be particularly useful to market gardeners.

Lawn treatments.—During recent years an increasing amount of work has been done in this country and abroad on the improvement of lawns. Whilst careful records have been kept of the changes brought about on the vegetation by various treatments, the effects on the soil have not been studied in most cases. On a lawn in the Institute grounds 70 experimental plots have been laid out, and thirteen different treatments have been applied. Differences in vegetation are already evident, and a chemical examination of the plots is being carried out.

The lime status of certain soils in the north-east of Scotland.—Laboratory and field investigations are in progress on the acidity and lime status of five soils. Two of these, from the neighbourhood of Aberdeen, are of granitic origin : one from Old Red Sandstone material near Laurencekirk : another from the basic complex near Belhelvie : and the fifth from olivine norite at Insch.

On each of these soils 18 plots were laid out—six receiving no lime, six receiving lime at the rate of 1 ton per acre, and the remaining six double that dressing. These plots are being cropped in the usual rotation (the crop in 1932 was oats in every case) and the yields weighed. The plots were sampled before liming and again at the end of the growing season, and determinations such as pH value, lime requirement, exchangeable bases, buffer capacity, etc., were carried out. In addition a corresponding set of experiments was done in pots, using oats, barley and mustard.

Joint investigation with the Rowett Institute.—An experiment is being carried out to observe the behaviour of certain ions in limed and unlimed soils, and for this purpose grasses are being grown in a series of Mitscherlich pots and the drainage collected. It has been observed that there is a very marked increase in the growth of the grasses in the limed pots in two of the soils.

A joint experiment with the Rowett Institute is also being carried out in the preparation of silage by the new A.I.V. process. Samples of the crop used and of the soil in which the crop was grown have been examined.

Joint investigation with the Animal Diseases Research Association.—The study of the problem in connection with the malnutrition of sheep in Tiree has been continued. An examination of the soils has shown that the soil from the "pining" area contains an abnormally large amount of lime in the form of shell sand. This has a marked effect in depressing the solubility of other plant nutrients, and the pasture is inferior to that on the good area. The total amount of iron present in the soil from the "pining" area is much less than from the good area : but it is probable that if

the pining is due to iron deficiency the effect is associated with the high calcium content.

The study of peat soils.

Macaulay demonstration farm, Lewis.—Satisfactory progress has been made with the development of the farm. The area under crop has been considerably increased, and improvements made on the drainage. Experiments to ascertain the best depth and distance apart of the drains are in progress. A section of road has been made through deep peat on a system which has been found successful in Germany (2).

The field experiments on the use of various artificial manures with and without lime have been continued, and a range of plots of grasses and legumes (with and without inoculation) has been laid down.

The principal crops grown this year were grass for pasture, hay and silage. A marked improvement was effected in the vegetable garden and it is evident that with suitable treatment a whole range of vegetables can be grown successfully on deep peat.

A paper by Mr. D. Clouston, of the North of Scotland College of Agriculture, describes experiments on the establishment of pasture on virgin peat, conducted by the Institute at the Demonstration Farm (5). An area of acid Scirpus peat was dressed with artificial manures and with varying quantities of lime, and five grass seed mixtures were sown. The establishment of pasture was very successful.

The number of cows has been increased and over 20 gallons of milk from tuberculin-tested cows are now being sold daily in Stornoway. The poultry work at the farm has also been considerably developed.

Without the whole-hearted co-operation of the County Work department of the North of Scotland College of Agriculture, this amount of progress on the demonstration farm could not has been achieved.

Laboratory and survey work on peat.—An area of peat land in the north of Lewis has been surveyed. The nature of erosion, depth and characteristics of the peat have been noted, and samples taken for chemical and pollen analysis. In this way it is hoped to trace the development of peat mosses under the climatic conditions prevailing in Lewis, and to ascertain the possibilities of their improvement for agricultural purposes. In addition peat samples have been taken in various parts of Aberdeenshire with a view to comparing these with the peats found in Lewis.

Soil surveys.

Soil survey work is being carried on in four areas :

(i) *The neighbourhood of Aberdeen.*—The soils are derived from glacial drifts of granitic and gneissic origin.

Under forests and heath they are of the podsolic type varying in degree of maturity.

(ii) *The neighbourhood of Insch.*—The parent materials in this area are very diverse and include granites, basic rocks and slate.

(iii) *The Howwood Valley in Renfrewshire.*

(iv) *Sand dune soils in Ayrshire,* between Irvine and Troon.

A paper was published, in which the scheme of classification of soil types in Russia is discussed (6). These types are found to be characterised by definite profile features and follow a zonal distribution roughly corresponding to the climatic zones. The characteristics of the various soil types, their development and distribution, are discussed. A short account is given of the relations of geology and vegetation to the soil types.

Geological work.

Determinations of the mineral content of soils of the north-east of Scotland have been continued. These analyses have been made with special reference to the relationship between the parent materials and the soils. Study is being made of the parent material, mainly boulder clays and sands and gravels, about the composition of which there is little information, and this study is also being linked up with the soil survey work. A special study is being made of the content and state of weathering of minerals furnishing plant nutrients in a selected number of soils.

The results of this investigation would indicate a general confirmation of the results obtained in a study of the soils of south-east Scotland, namely, that in all the Scottish soils examined there is a fairly high proportion of unweathered material and a considerable variation in the mineral content of individual soils. In the soils of the northern area, however, the content of ferro-magnesian silicate minerals is much higher than in the south-east, especially in the areas of igneous rocks, the minerals generally being in a much fresher state. The mineral content can be used to grade the soils, and appears to be linked up with the solid geology of the area, though the presence of glacial drift renders this derivation indirect.

A progress report (3) was published in connection with the compilation of information on drift and peat recorded by the Geological Survey in two Maps and Memoirs. All the information relating in any way to soils, peat, superficial deposits and occurrence of limestone was collected from the six-inch field maps.

Field work for the collection of material for study has been carried out, mainly in the Aberdeen district. Some time was also spent in the spring and summer preparing material for the visit of the Soil Correlation Committee to Scotland.

Craibstone draingauges.

The lysimeters at Craibstone were in 1931 under third-year grass, which was treated under the system of manuring intensively with sulphate of ammonia after a dressing of phosphatic and potassic manures had been given. This was done to ascertain how far the nitrogen used in this intensive treatment of grassland is utilised by the crop, and how far it is lost in the drainage, and what is the effect of its use on the other constituents of the drainage.

Lysimeter No. 1 was, as usual, unmanured, while Nos. 2 and 3 received a total application of 4 cwts. of sulphate of ammonia per acre. The first dressing, 1½ cwt. per acre, was given in March, and further dressings were given in May and September. The crop was cut at frequent intervals, weighed, the amount of clover in each cutting determined and analyses made. The composition of the drainage and the amount of nitrogen contained in it was also determined. Although the season was a comparatively wet one the results seem to emphasise two things :

(i) that even when sulphate of ammonia is applied in such quantities as are ordinarily given in the intensive manuring of grassland there is no danger of any loss of the nitrogen in the drainage from land which is covered with grass, at any rate in a climate such as that of east Scotland.

(ii) that the claims which have been made that extraordinary increases are obtained in the amount of food produced by pasture intensively manured have not been realised in this case. Lysimeter No. 1 has not been manured with either dung or artificials for many years, and has been continuously cropped. On the other hand, Nos. 2 and 3 have been well manured with both dung and artificials, and for the grass crop of 1931 received a good dressing of phosphate and potash, and also sulphate of ammonia at the rate of 4 cwt. per acre, yet the return for all this was an increase at the rate of only 6 cwt. per acre of dry crop in the case of No. 2. No. 3 consistently gave bigger crops than either 1 or 2, even in the preliminary tests which were made before any of them was manured. It has a rather deeper and better soil than either of the others, and it has been limed while the others have received no lime, yet the increase in this case was only about 11 cwt. of dry matter per acre. Further, the pasture yielded by Nos. 2 and 3 was far poorer in clover than on the unmanured No. 1, and this poverty in clover seems to have been due to the heavy nitrogenous manuring, for in 1930, before this manuring began, Nos. 2 and 3 bore far more clover than No. 1.

As these results were unexpected the lysimeters during 1932 are being treated in a similar manner to that of 1931 to find if the results obtained for that year are confirmed in a second season (4).

Titles of papers issued during the year.

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2. Ogg, W. G., and Macleod, A. : Reclamation and Cultivation of Peat Land in Lewis. *Ibid.*, **15,** No. 2, 1932.
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4. Hendrick, J., and Welsh, H. D. : Intensive Manuring of Grassland. *Trans. Highland and Agric. Soc. Scot.*, **44,** 86–96, 1932.
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3. CHEMICAL (AND ANIMAL NUTRITION) DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Soils and fertilisers.—Further work has been done on the subject of the manuring of newly reclaimed bogland. The results show conclusively that a moderate dressing of lime (about 2 tons burnt lime per acre) combined with farmyard manure must form the basis of manuring for successful crop production.

Liberal dressings of complete mixtures of artificial manures in conjunction with the above gave the best results. Yields of nine tons of potatoes per acre were obtained. This work is being continued.

Data on the " liming " of arable land are also being collected from the point of view of yield and mineral composition of herbage.

A further number of soils have been examined by the Mitscherlich pot method for determination of manurial requirement and in each soil examined large phosphate deficiency was indicated. This is in general agreement with the large response obtained, in Northern Ireland soils, from phosphatic fertilisers.

Field experiments are being conducted in order to test the accuracy of the quantities of fertilisers indicated by the method as being deficient in the various soils.

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4. RESEARCH INSTITUTE FOR PLANT PHYSIOLOGY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

The work of the Institute is directed to a study of the plant physiological processes concerned in crop production. The Institute works in close association with the Institutes at Rothamsted, East Malling and Cheshunt.

Crop yield and the interaction of factors.—In the last report reference was made to the importance of the view, developed by the Institute, of the interaction of factors in crop yield. Reference was also made to an experiment on cotton carried out in the Sudan with the help of the Institute. The design of the experiment (which was of an elaborate nature) was based on this modern view of the "interrelationship of factors." The results of the experiment which have now been published (7) are so striking that some of the outstanding features of the experiment and of the conclusions reached may be briefly stated. The interaction of the four controllable factors in the production of cotton under irrigation was studied, the factors being date of sowing (four sowing dates), amount of water applied (three water duties—light, medium and heavy), the spacing of the plants (three spacings—close, medium and wide), and nitrogen application (ammonium sulphate and controls without ammonium sulphate). These factors at their varying levels were combined in all possible ways, giving 72 combinations; each treatment was replicated four times, giving in all 288 plots. The experiment occupied an area of 10 acres, and was repeated in two consecutive years.

The yields obtained in these two years differed by 30 per cent., but it was found that the differences in yield for the two years were nearly constant for all the treatments. It is, therefore, clear that the yield differences for treatments in the two years cannot have been due to the climatic conditions at particular stages in the growth of the plants, seeing that the experiments included plants of different sowing dates and therefore in different stages of growth at any one time. The cause of the large annual fluctuations in yield must, therefore, be sought in some change in the soil induced by climatic conditions prior to the period of sowing. The results indicate a change in the availability or rate of supply of nitrogen in the soil.

The experiments show very clearly that no single factor is "limiting" at any one time, but that the effects of each factor in turn are dependent on the level at which the others are maintained. For example, in general the effect of increasing water application is very small unless nitrogen has also been supplied, thus demonstrating the interaction of these two factors. The generalisation must however be qualified as there is a further interaction of these two factors with sowing date. Thus with early sowing, in the absence of added nitrogen, differences in water application have little effect, whereas with nitrogen applied, yield increases markedly with increase in water supply. With late sowing, on the contrary, water supply has little effect irrespective of nitrogen application, thus demonstrating the interaction of three factors.

The design of the experiment in accordance with sound statistical requirements has enabled the significances of these interaction effects to be established beyond doubt. The main results may be

summarised as follows :—(i) Yield both with and without nitrogen application has a marked optimal sowing date. (ii) The increase in yield with nitrogen application declines with advancing sowing date. (iii) Spacing has little effect with early sowing date irrespective of nitrogen application, but with late sowing date the spacing effect is large, irrespective of nitrogen application. (iv) Water supply with early sowing date and nitrogen application has a large effect on yield ; without extra nitrogen, water supply has little effect. (v) The effect of water supply tends to disappear with advancing sowing date, irrespective of nitrogen application. The experiment has demonstrated the possibility of establishing in a single season the limits between which, by suitable adjustment of the levels of the factors, the yield of a crop may be improved or controlled.

Effects of mineral deficiency.—The investigation on the physiological effects of manurial elements and their deficiencies has been considerably extended. In particular, the nitrogen metabolism with deficiencies of the three chief elements, nitrogen, phosphorus and potash, has been studied. Estimations of nitrogen in various forms—total nitrogen, protein, amino-, amide, nitrate and ammonia —have been made on each successive leaf on the main shoot, and at various times. The changes in amount and relative quantity of the various forms of nitrogen throughout the life of the plant, and in the successive stages of each leaf are therefore known. The outstanding effects noted have been the accumulation of amino-nitrogen with potassium deficiency, and of amide-nitrogen with phosphorus deficiency. Simultaneously, a study of the sugar content has been made, so that the interaction of carbohydrate metabolism and of nitrogen metabolism in their relation to manurial deficiencies are beginning to be understood.

Potassium supply and metabolism.—The work on the relation of potassium supply to respiration has been published (8), and further work has been carried out by a different method. Besides confirming previous work new aspects of the problem have been revealed. The change in respiration rate under complete starvation conditions has been shown to be dependent on the level of nitrogen manuring maintained. The relation of respiration to amino-acid content has been demonstrated. A beginning has also been made in the analysis of the relation of potassium deficiency to the water-content of the barley plant. It has been shown that the water-content depends on a complex interaction of effects of the various nutrient elements present, and is an instance of the effect of the " physiological balance " of the nutrients supplied.

Electroculture.—The pot-cultures of 1931 show even more definitely than in previous years the relationship between electrification and nitrogenous manuring. The increase in grain yield due to the discharge was found only with a medium nitrogenous

manuring of 2 gms. sodium nitrate per pot, manurings considerably above and below this level giving no significant increase. The effect of the electrification in reducing the percentage of sterile flowers and so increasing the fertility of the ear has again shown itself. The effect is greatest on the ears which, without electrification, would show about 19 fertile flowers. Experiments were made with plants in which the tillers were removed as they appeared above the ground, with the result that these "detillered" plants bore a single main shoot. The ears on such shoots of electrified plants bore "more fertile" flowers than those on the similar shoots of the control plants (2).

After-effect of temperature on winter cereals.—Work has also been continued on the analysis of the after-effects of the temperature of germination on the flowering and fruiting of winter varieties of cereals. The effect has been shown to depend on the length of day to which the plants are exposed. The relation of this interaction to the question of mineral nutrition is also being studied.

Physiology of tomatoes under glass.—A study is in progress at the Cheshunt Experimental Station of the effect of light and temperature on the growth of tomatoes under glass. Among other results, there are indications that a high or low night temperature may affect the activity of the leaves the next day.

Chemical studies of the physiology of apples.—Work has been continued on the physiological processes concerned in the ripening process of the apple. Particular attention has been paid to the changes in starch and hemicelluloses, and to the effect of time of gathering on the changes which occur in the fruit in cold storage (9).

Studies have also been made of the conditions which control the intake of water by plant cells and tissues (5) and of the physiological effects of X-rays, and ultraviolet light on plants (3, 4).

Titles of papers issued during the year.

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B.

PLANT BREEDING, CROP VARIETIES and SEEDS.

5. PLANT BREEDING INSTITUTE, CAMBRIDGE UNIVERSITY.

Wheat.—Most of the work was a continuation of that described in the report for 1930-31. Another series of baking tests carried out on the produce of the Yeoman x White Fife hybrids grown by the National Institute of Agricultural Botany again showed that some of them were substantially stronger than Yeoman II. The best form was therefore used as the starting point of a new series of hybrids, the second parents being for the most part hybrids obtained in previous years and characterised by outstandingly good straw and rust resistance and, in view of the possible demand for spring wheats, with some of the best early maturing forms from the Chinese × Yeoman series. The object is to produce a number of strong forms suitable for cultivation over a wide range of soil and climatic conditions. The usual detailed examination of the F_2 and F_3 generations will be impracticable owing to limitations of space and time, and the intention is to pick out the strong forms at the F_2 stage and grow them on as mass cultures, leaving the work of rigid selection to the F_6 or F_7 stages. This labour-saving expedient has been adopted with some of the current season's F_2 generations.

The examination for quality of the Chinese × Yeoman wheats was continued. As these are at the F_7 and F_8 stages they should be reasonably homozygous. But stray rogues still appear in the cultures as the results of outcrossing to which they seem unusually liable. Total nitrogen and chewing tests indicate that amongst them are a number of strong forms. As sufficient grain for small scale baking trials is available, preliminary tests will be made as opportunities occur during the winter months. The series is of interest in other directions as well, for some members of it show a particularly high bushel weight and others are characterised by setting more grains per spikelet than any other wheats grown at the Experimental Station.

The more purely genetical investigations in progress during the year were concerned with the study of rust resistance in interspecific crosses. Attacks of greater severity than those occurring on the parents were again met with, especially amongst crosses with *T. turgidum*, but the numerical data are still too scanty to help much in an interpretation of the phenomena. The systematic study of the segregation occurring amongst such crosses was continued with results which may be useful in synthesising new forms of bread wheats. An investigation into the inheritance of " finish " in grain was also continued. The term " finish " is used to describe the capacity possessed by a few hybrid wheats to produce exceptionally well filled grain. It appears to be independent of season. It, in conjunction with a rounded grain shape, is responsible for the high bushel weight of certain of the Chinese × Yeoman derivatives. The same material was also used for an investigation on the

inheritance of number of flowers per spikelet, as the character may be of importance in the production of high yielding forms. Another series of hybridisations was undertaken in connection with an enquiry, now four years old, into the subject of hybrid vigour in wheat. A paper upon the results will be published shortly showing that, as yet, there is nothing to indicate that any practical advantage from the utilisation of hybrid vigour can be obtained with this crop.

Winter oats.—In 1930 a series of the best selections of the hybrid Argentine × Grey Winter was handed to the National Institute of Agricultural Botany for propagation, and sufficient seed was raised therefrom to carry out the ordinary drill-strip tests in 1931-32. Concurrently the Plant Breeding Institute carried out small scale comparisons with most of the same selections in the two seasons 1930-31 and 1931-32. The results of these two sets of comparisons are substantially the same, and two of the selections are now regarded as being sufficiently promising to justify propagation on a large scale.

The number of promising winter varieties has been augmented by a series obtained from an Argentine × Grey Winter selection. Apart from their ultimate origin, which is largely a matter of conjecture, these oats are notable by reason of their good standing straw, the quality of grain and their winter-hardiness. The most promising selections of this series were grown in drill plots in 1931-32 and seed from one lot has been handed to the National Institute of Agricultural Botany, who are conducting a preliminary trial with it this autumn (1932).

A further series of winter oats of considerable promise is the F_3 generation of a cross between 136/17 (one of the Argentine × Grey Winter selections now being increased in bulk by the National Institute of Agricultural Botany) and Grey Winter. From this generation a number of selections have been made and sown this autumn. Selections of other hybrids such as Bountiful × Grey Winter have been advanced to the F_6 generation. These selections in many cases are characterised by grain of the highest quality. This is not invariably found in association with good standing straw, but the less satisfactory forms are being gradually eliminated and there is now reasonable prospect of ultimately securing selections in which these attributes are realised in combination.

Spring oats.—From the hybrid Argentine × Grey Winter a number of strictly spring oats has been obtained. In dealing with these oats the objective has been a grain-quality approximating as near as possible to that of the parent Grey Winter. Up to the present, however, although a high quality in the grain has been obtained this has not been found in association with the desired strength of straw ; moreover, most of the spring forms have exhibited a decided tendency to Grey Spot. These two features have necessitated further crossings with the best varieties and hybrids characterised by good straw and by freedom from Grey Spot.

Some of the most promising forms from Banner × Black Tartary and Argentine × Black Potato were tested quantitatively this year and the results indicate the desirability of prosecuting the cultivation of at least two selections, particularly in districts where varieties of the Black Tartary and Potato type are grown extensively.

Barley.—Eight hybrids, six in the fifth generation, and two in the seventh generation, have occupied most of the attention this year. These hybrids are the progeny from crosses between some of the best two-row varieties grown in this country at the present time. The crosses were made with the idea of selecting new varieties either of better malting quality than those varieties in existence already, or varieties which will produce first-class malting barley under a wider range of conditions.

A total of seventy cultures distributed between the eight hybrids, the result of previous years' selection, were sown this year. Unusually large amounts of each culture were sown as it was intended that this should be the last year for selection before giving the final selections a yield trial. These cultures compared very favourably with the standards—Spratt-Archer and Plumage-Archer—in all respects. It is now intended to put the final selections into a yield trial next year, as even a first-class malting barley is useless unless it can yield reasonably heavy crops.

With the purpose of searching for new varieties that may have some economic application in this country, a large collection of forms was introduced from the United States. The particular object was varieties of high yielding power and strong straw. If this country is to produce more feeding stuffs, such high-yielding forms should be of value, particularly for the pig industry. Further, a good six-row barley is being sought after for crossing with our first class malting barleys in an endeavour to produce a six-row malting barley that can stand winter sowing.

The great majority of the American barleys have shown themselves to be of no value, but about fifty six-row forms have been retained out of about three hundred and fifty, and they are being tried again this year. The best of these will be used in further hybridisations with English varieties.

A large series of crosses was made this summer between the best of our two-row malting barleys and some six-row forms which have been under observation for some years. It is hoped that selections of first-class six-row malting barleys will be possible from some of these crosses.

Sugar beet.—The work on this crop was started some years ago because it was considered that, if the crop could be grown profitably in this country, a supply of home-grown seed should be available. It also seemed desirable to acquire further information on the technique of raising improved forms of cross-pollinated plants. Hitherto most of the successes the plant breeder can point to have been secured with plants which are normally self pollinated and a

general survey of the subject shows that long continued mass selection more than anything else accounts for the improvements effected in cross-pollinated plants.

An attempt was made to circumvent the difficulties associated with out-pollination by searching for self-fertile plants amongst the medley of self-sterile forms present in commercial crops. But whilst indications of different degrees of self-fertility were found, it soon became evident that far larger numbers of plants would have to be examined than could be handled by the staff of the Institute. Concurrently, a small stock of seed from crosses between parents of known sugar content, but unknown genetic constitution, was worked up, and plots have been grown from a portion of this for comparison with two commercial strains. The sugar determinations of the individual roots will be made in the course of the winter and if any exceptionally good roots are met with, the problem of carrying the work on to the commercial stage will have to be faced.

Peas.—The single plant selections of English varieties were again tested last year by the National Institute of Agricultural Botany. A very short strawed hybrid form was also tested, and the work presented unexpected difficulties. It is feared that shortness of straw, while an undoubted asset in connection with the harvesting of the crop, may be a severe disadvantage because of the inability of the plant to check weeds on any but clean land. This point is being further investigated in conjunction with the National Institute of Agricultural Botany during the coming season.

A series of hybrid peas, all of Maple type, was tested on a small plot-replicated system last year. The results were encouraging and the best of the hybrids will be handed over to the National Institute of Agricultural Botany next year.

Sainfoin.—Investigations with this crop which were commenced in the autumn of 1931 have been continued, their objective being the provision of pure stocks of true winter and spring forms. Once these are obtained, the work will be pursued in the direction of selection within such stocks.

Titles of Papers issued during the year.

1. Watkins, A. E., and Cory, F. M. : Genetical and cytological studies in wheat. V. *J. Genet.*, **25**, 55, 1931.
2. Watkins, A. E. : Hybrid sterility and incompatibility. *Ibid.*, **25**, 125, 1932.

6. WELSH PLANT BREEDING STATION, ABERYSTWYTH.

Introduction.—The main researches of the Station are financed partly from the Development Fund and partly from the Empire Marketing Fund. Special grants are also made to the Station from

the Development Fund for research on the improved management of grassland (see p. 387), and from Messrs. Imperial Chemical Industries, Ltd., for general grassland researches.

The work is being continued precisely on the lines indicated in the last report, and every endeavour is made to bring all the researches to bear on our main problem, *i.e.*, to assist towards the accumulation of a fund of knowledge that may be placed at the farmer's disposal relative to establishing and maintaining good grass under the widest possible range of conditions. With a view to this end, and in order to encourage ploughing as a means of establishing good grass, great emphasis is laid on standing ability in connection with all our work on oats. The progress which is being made with the various investigations is indicated by the notes which follow :

Oats (Mr. E. T. Jones).

White winter oats.—Yield trials with segregate strains of the cross Kyko × Grey Winter have now been brought to a conclusion (1). The two selected strains, S.81 and S.82, have again in the past season continued to give yields of grain superior to both Grey Winter and Unique, and also straw with increased resistance to lodging. In 11 trials, extending over five seasons, these two strains have now given average grain yields of 14 and 9.5 per cent. respectively more than the check variety Grey Winter.

Four new segregate strains derived from the crosses Black Winter × Grey Winter, Marvellous × Grey Winter (two strains), and a selected segregate ex Black Winter-Grey Winter × selected segregate ex Kyko-Grey Winter respectively, have in the past season's trials shown considerable promise in respect of earliness, size and quality and yield of grain and resistance to lodging relative to S.81 and S.82 strains. Their position with regard to winter-hardiness, on account of recent relatively mild winters, however, still remains undecided. The strain developed from the " selected segregates " cross possesses extremely rigid straw and, although in this particular strain the grain is not very large, its yield in the past season compared quite favourably with S.82.

The trials in the 1932-33 season are being confined to the four new strains—Grey Winter and Unique being used as checks.

Spring Oats.

(i) *For good land.*—Further data have been collected during the past season on yield and other characteristics of 38 strains of crosses, mainly of Victory-Algerian and Victory-Record origin. The former continue with few exceptions to give yields of grain and resistance to lodging superior to the check variety Record. In the coming season it is hoped to be able to test some of these on a preliminary drill-strip basis in the counties.

(ii) *For moderate land.*—Of the Record-Radnorshire Sprig segregate strains, many continue to give promise in the yield trials, and a few which have done well in the past three seasons' trials are being tentatively multiplied for strip trials in the counties next year. Twenty-eight strains were tested in replicated rod row beds and fourteen in replicated 1/100th acre plots in 1932.

(iii) *For upland conditions.*—Strip trials have in the past season been conducted with three *Brevis-strigosa* segregates at two upland farms. Two of the three did well and will be tested again in 1933. In a yield trial at Frongoch, all three gave both more grain and more straw than the check variety *A.strigosa.*

Genetics.—The study of the segregation of the grain characters articulation, pubescence and awn in the diploidtetraploid (*A. brevis-A. barbata*) cross has been continued and some new crosses between selected segregates and the diploid parent have been made.

Hybrid grains have also been obtained by pollinating *A. Abyssinica* with *A. sativa.* These "pentaploid" F'.s will be under study in 1933.

Cereal Synonyms.—In connection with the study of cereal synonyms of oats representative plots of several suspected synonyms and their type varieties have been studied in co-operation with the Cereal Synonym Committee.

Herbage Plants: Breeding.

Grasses (Mr. T. J. Jenkin).—Notes are given as to the position of the work relative to the chief species under investigation.

Perennial rye-grass.—In this species, as in others to be referred to below, the search for exceptionally promising plants for use as parents has been pursued by the study of single plants. Plants similarly selected in previous years have been intercrossed for the purpose of studying their progeny, while in other cases this detailed work of the selection of parents by the progeny test has been carried on still further. At the same time, new potential strains produced on these lines have been studied in relation to existing strains and the ordinary commercial.

It has been found that the isolation of small lots of basic plant material, by resort to greenhouses, has not been as satisfactory as in the case of cocksfoot and other grasses. The matter is under further investigation.

The two strains, one a hay type and another an extreme pasture type, which were first evolved, are still being carried on, but the former is not in every respect satisfactory. In particular, it has been found to be too susceptible to autumn rust. In this strain, therefore, vigorous re-selection is being pursued. Some amount of re-selection work is also being made in the extreme pasture type, and, in fact, it is now being re-established on an improved basis.

In addition, three other strains are being propagated. One of these is a relatively early but very grassy type. This strain aims at a type which continues to produce a good base even when the plants are flowering and ripening seed.

In the second strain, the emphasis is placed upon bulk of leafy herbage, particularly about July. This type is regarded mainly as a " late hay " type, but since the basic plants are selected from good old pastures, the type is expected, and promises to be much more persistent than the ordinary commercial type. The third strain is of the extreme pasture type, and will quite possibly be merged in the existing strain as the types are not profoundly different.

Timothy.—Work is proceeding on lines very similar to those described for perennial rye-grass, but in the case of timothy more attention is given to the improvement of the four existing strains than the development of new ones. In particular, the elimination of inferior types and especially of plants heterozygous for rust resistance is given attention. In this connection, a research student is at present making a study of the inheritance of rust resistance in timothy, following up some work which Mr. Jenkin had already started. The problem is, however, a difficult one, but useful results may confidently be expected.

Red Fescue.—The old strain, based upon B1 728, is now practically a commercial commodity and although not designed for that purpose, reports have been received from the Golf Greens Association at Bingley showing that it is proving to be a very promising type for the establishment of golf greens. It is also continuing to do well for the purpose for which it was mainly intended.

Re-selection within the strain is being pursued with a view to obtaining a greater degree of uniformity of type and vigour.

A second strain of a more widely and densely creeping type is now being developed.

Sheep's Fescue.—In view of the possible importance of this species in connection with the improvement of hill pastures, the work on it is receiving increased attention, but so far nothing has been found to be a definite improvement upon the existing strain, B1 727.

Poa species.—The two strains of *Poa pratensis*, Bp 89 and Bp 90, are being carried on and are being studied with a view to the elimination of the less satisfactory.

Another strain of a very different type is now also being increased provisionally for trial.

Further material is under study with a view to producing yet other strains.

Little work has been done with *Poa trivialis*, but the study of single plant lots of different sources of origin has been re-started.

Phalaris species.—No work is being done on the improvement of existing *Phalaris* species, but attention is still being given to the derivatives of the inter-specific cross *Ph. arundinacea* × *Ph. tuberosa*. A paper dealing with these hybrids has been published (2).

Some relatively true-breeding material has now been evolved which is definitely different from both parent species. This material has attracted considerable attention, particularly from Australian visitors.

Genetical.—Genetical work with the grasses is largely confined to perennial rye-grass. Here the difficulty is not to find characters (particularly seedling characters) for study, but to refrain from trying to study too many. The amount of work of this type that can be done in a season is very strictly limited by the shortness of the effective hybridisation season and the technical difficulties involved.

At present, main attention is given to the characters' dwarfism and one type of chlorophyll deficiency. This problem, which originally appeared to be relatively simple, is proving to be very complicated, and probably involves two cases of linkage.

The work in rust resistance in timothy has already been referred to.

The work on inter-generic and inter-specific hybridisation in the grasses, particularly *Lolium* and *Festuca*, is still being pursued, but this work is necessarily slow.

Very valuable information concerning these crosses has been obtained through the work of the research student, Mr. F. H. Peto, who studied the detailed cytology of some of the plants. Mr. Peto has now completed his particular study, but a very large amount of material still remains to be studied in the same way before the work can be considered to be in any sense complete.

Legumes (Mr. R. D. Williams).

Red clover.—During the season the majority of the most promising red clover families were crossed *inter se* in various combinations. These crosses will be subjected to progeny tests in order to find the best combinations for the purpose of strain building. Most of the best families were also in-bred with the view to further purifying them.

During the course of the season several very promising new families were isolated. A sufficient number of families of outstanding merit is now available to allow a larger number of such families than was hitherto possible to be included in new strains, thus reducing the chances of degeneration resulting from in-breeding.

Last summer six new strains, each consisting of 6 to 10 unrelated families were built. Two of these were of the Montgomery-Cornish Marl type, one English late-Swedish late type, two late × wild types, and one wild red type.

A field trial of ten new strains was laid down during the spring at the Plant Breeding Station farm, and two similar trials involving five of these strains were sown in the counties.

Sufficient seed was obtained this summer from new strains planted out in 1931 for carrying out field trials next year.

White clover.—A large number of new crosses, involving wild white types, large-leaved New Zealand types, small-leaved mountain types were made during last summer.

Sufficient quantities of seed of a luxuriant, quick-growing, large-leaved strain which is intended to take the place of Dutch white clover and of a persistent type of wild white were obtained last summer, and it is proposed to carry out field tests with them next year.

The large-leaved type mentioned above would seem to be sufficiently promising to multiply on a large scale with a view to placing it on the market at an early date.

Lucerne.—Attempts were made during last summer to synthesise three new lucerne strains from the best available lines, but as the conditions proved unfavourable only a small amount of seed was obtained.

Other legumes.—The work on kidney vetch, crimson clover, trefoil, and *Lotus* was continued.

Clover investigations.—Many genetical problems, most of which have a direct bearing on practical breeding, are being investigated, and as an outcome of these studies a great deal of interesting information has already been obtained concerning such problems as effect of inbreeding on vegetative vigour, inheritance of earliness, persistence, leaf size, self- and cross-sterility, chlorophyll defectives, and other lethal and sub-lethal types, hairiness, flower colour, seed colour in red clover, and the inheritance of cyanogenesis, self- and cross-sterility in white clover.

It is proposed to publish the results of some of these investigations this winter.

Grassland Agronomy.

Important aspects of the work have been reported in connection with (*a*) the work of the Grassland Adviser (see p. 385) and (*b*) investigations on the improved management of grassland (see p. 387). Some further particulars of the investigation as a whole may be given here.

Trials with sheep (Mr. Ll. Iorwerth Jones).—The first experiment set up with tethered sheep has now been completed and reported upon (4). The results would seem to indicate that in this district wild white clover has a very high feeding value, and also showed than a simple mixture (indigenous rye-grass, rough-stalked meadow grass, and wild white clover) gave better live weight increase than plots consisting of single species.

Since this preliminary experiment showed that the technique appeared to be satisfactory, a considerable experiment was set up to endeavour to test the feeding value of pure cocksfoot against pure rye-grass, and to further test the influence of wild white clover. The results for the first year are now available for this experiment. The evidence appears to show that perennial rye-grass has a decidedly higher feeding value than cocksfoot, while the plots which included wild white clover gave an average of 15 per cent. more increase in live weight than the corresponding plots without wild white clover. The effect of the length of the rest period on the live weight increase of sheep is being further investigated. The trial previously conducted is now being repeated on a sward particularly full of wild white clover. On such a sward and in a good growing year a month's rest, as is to be expected, proves too long and the best results have been obtained off the folds subjected to only two week's rest.

The work on the effect of differential grazing (by resort to tethered sheep) is being continued and extended, and is now also being applied to seeds mixtures with results that promise to be of great significance.

Seeds mixtures (Mr. W. E. J. Milton).—Two extensive series of seeds mixture experiments have been set up during the season with a view to studying the competitive influences of different strains of the same species when sown in comparatively simple mixtures.

Seedling establishment under different conditions (Mr. T. E. Jones).—This work is being continued and extended. Under poor conditions on the hills the only species that seem capable of making even feeble establishment are bent and Yorkshire fog and cocksfoot to a slight extent. The addition of phosphates has a marked influence on the establishment of grass species, particularly in the case of the species mentioned above; it also makes establishment with perennial rye-grass and other grasses a possibility. With complete manures both establishment and growth are further improved.

Empire Marketing Fund Grant.

Seed production and isolation (Mr. Gwilym Evans).—In the spring of 1932 the seed of seven pedigree strains of grasses were released to the trade for multiplication. These included one strain of cocksfoot, four of timothy, one of rye-grass, and one of red fescue.

Forty acres of pedigree grasses and clover were harvested during the year 1932, and eighteen additional acres were sown down. In all, the seed from thirty strains, eighteen of grasses and twelve of clovers, was grown in ten counties by thirty-three growers. The main bulk of the seed was produced in two districts, namely, the

Welshpool district and in the Wye Valley. The first multiplication of new red clover strains on the other hand was chiefly conducted in non-arable districts, such as the Towy Valley.

Harvesting conditions were favourable on the whole, and the quality of the seed appears to be as high as any imported from the best seed-growing countries.

Two pedigree strains of red clover were carried to the second multiplication stage by the sowing out of three acres, which will be harvested for seed in 1933.

Further progress has been made with a view to the better understanding of the proper methods for growing remunerative seed crops on a field scale as applied to different types of pedigree grasses. Two aims have been kept constantly in view: (*a*) to increase the yield of seed, and (*b*) to reduce the cost of production.

Problems peculiar to indigenous grasses in connection with the dressing of their seeds have been investigated and appropriate machinery has been designed to overcome various difficulties.

Preliminary studies have been initiated by resort to a new technique with a view to measuring the efficiency of distance isolation for seed production in the case of both cross-fertile grasses and clovers.

Plant physiology (Mr. H. G. Chippindale).—The work on delayed establishment in some species of grasses is being continued and important results from these investigations have been published (5). Arising out of this work, an investigation has been commenced into the relations between the mineral nutrition of grass-seedlings and their reaction to diminished illumination.

A detailed study has been made of the exact manner in which soaking the "seeds" of cocksfoot in water causes an acceleration of germination. It is hoped to publish this work in the immediate future.

Further experiments are being conducted on the germination of grass "seeds" in solutions of cane sugar ("suction-force" determinations), but little material is available that is suitable for this purpose.

The work on peaty hill soils is continuing: it is probable, however, that another season's growth will be required (making three years' growth in all) before a definite account of the results can be provided.

The investigations which have been in progress for some time (6) on occurrence of buried weed seeds in the soil underlying pastures of various types have been continued and a report on the first batch of fields investigated will be published at an early date.

Reports on strains of grasses and clovers.—The station continues to receive samples from overseas for report, and this incidentally provides valuable plant material in connection with its breeding work. During the period under review, 18 reports involving 190 samples, were sent out.

Titles of papers issued during the year.

1. Jones, E. T.: New varieties of white winter oats. *Welsh J. Agric.*, **8**, 102–24, Jan., 1932.
2. Jenkin, T. J., and Sethi, B. L.: *Phalaris arundinacea, Ph. tuberosa,* their F_1 hybrids and hybrid derivatives. *J. Genet.*, **26**, 1–36, July, 1932.
3. Williams, R. D.: Effect of a nitrogenous manure on white clover and a comparison of the productiveness of four types of white clover under simulated pasture conditions. *Welsh J. Agric.*, **8**, 163–70, Jan., 1932.
4. Jones, Ll. Iorwerth: Preliminary experiment to test the reaction of sheep (live weight increase) to different species and strains of grasses and clovers and to test the yield and other characters of the species as such. *Welsh P. Breed. Sta. Bull.*, Series H.13, 95–121, Oct., 1932.
5. Chippindale, H. G.: The operation of interspecific competition in causing delayed growth of grasses. *Ann. Appl. Biol.*, **19**, 221–42, May, 1932.
6. Chippindale, H. G., and Milton, W. E. J.: Note on the occurrence of buried seeds in the soil. *J. Agric. Sci.*, **22**, 451–2, July, 1932.

7. SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING, EDINBURGH.

Cereals.

Oats.—An extensive collection of unfixed hybrids was grown, and further progress was made in eliminating those selections which did not appear to come up to the required standards as regards type of straw and grain, and time of maturity. In view of the encouraging results obtained from using the Potato oat as a parent, several F_2 generations of Potato oat crosses were grown for observation. Detailed notes were made on a few F_2 families regarding the inheritance of grain colour (6), type of ear, and striped leaves.

Many early-ripening hybrids of different parentage have been grown and selections made over a period of several years. The most outstanding of the fixed types are now being increased in quantity in order to have them included as soon as possible in preliminary field trials.

Twenty-one fixed hybrid selections which had reached the field trial stage, and nine named varieties, including Victory, Record, Marvellous, Elder, Potato, and Sandy, were grown in replicated trial plots. The data obtained for yield of grain from these trials were examined statistically and comparisons made. A group of early-ripening, white-grained selections from Orion crosses was included in this trial, and some of the less promising selections of this group are now being discarded. One of the most promising selections is a vigorous growing variety from the progeny of Sandy × Orion. This variety ripened about a week earlier than Sandy and gave a significantly higher yield of grain. Among other selections which merit further trial are several secured from the progeny

of Potato × Record. They have good upstanding straw, and have given good yields of attractive grain. One of these Potato × Record selections was included in the Registration Trials of the Department of Agriculture for Scotland in 1932, and it will probably be tried on an extended scale in 1933.

The fixed hybrid selection (Sandy × Leader) which was referred to in the report for 1931 as having been recommended for registration, was registered by the Department of Agriculture for Scotland in January, 1932, and was named "Bell" (5). All the available seed (about 2½ tons) of this new variety was sold early in 1932 to members of the Society, and many favourable reports on the 1932 crops have been received. In view of the demand for the 1931 crop of seed, three acres of Bell oats were grown by the Society in 1932 for seed.

About nine tons of seed of the "Elder" oat (5), were sold to members of the Society in the spring of the year under review.

Wheat.—A group of hybrid wheats was grown for the purpose of selecting the more promising winter-hardy plants, and various types have been retained for further trial in 1933.

Barley.—A valuable collection of hybrid barleys was received from Mr. Thomas Anderson, Director of the Seed Testing Station, Corstorphine, and these, together with a few hybrid selections raised at the Plant Breeding Station, were grown in small observation plots in 1932. Several of the selections are early-ripening types which may be well adapted to agricultural conditions in certain parts of Scotland. A few of the most promising of these hybrids have been retained for further trial on a larger scale in 1933.

Potatoes.

Work was continued along lines similar to those of previous years. Further information was collected during the year regarding :—

(i) the effects of repeated self-fertilisation ;
(ii) the relative value of different pairs of varieties as parents for the production of economic types of seedlings ;
(iii) the progenies obtained by crossing cultivated potato varieties with certain wild tuber-bearing Solanums.

The heredity of various botanical characters was studied, and, in addition, cytological investigations were made on several species of wild tuber-bearing Solanums. Among these wild Solanums as well as among cultivated potato varieties, progress in the genetical studies is greatly hindered by the incidence of sterility.

Over 2,000 first-year seedlings were raised at the Society's sub-station at Ainville, Kirknewton. About 1,400 of these were obtained by hybridisation and the remainder by self-fertilisation. The more important botanical characters of all the seedlings were carefully compared and the more promising types retained for further

trial. The second-year seedlings, numbering about 500, were grown in small plots and examined mainly from an economic standpoint, and compared with standard commercial varieties. Over 150 older seedlings were included in these trials. An additional trial of about 240 seedling selections raised in previous years at Ainville sub-station was also carried out at the Plant Breeding Station, Corstorphine.

Seedlings from the stocks grown at the Society's sub-station were included in the various trials conducted by the Department of Agriculture for Scotland at Philpstoun ; at East Craigs, Corstorphine ; and, in the laboratory Wart Disease immunity tests, at the Seed Testing Station, Corstorphine.

Four seedlings were included in the first-year and one in the second-year Registration Trials arranged by the Department of Agriculture for Scotland. Two seedlings in the first-year trials failed to reach the required standard, but it is understood that the others will be recommended for inclusion in the Registration Trials in 1933.

As a result of the preliminary trials at the Plant Breeding Station, Corstorphine, several new seedlings will be sent for inclusion in the Department's first-year Registration Trials next season.

Herbage Plants.

The timothy grasses as represented by the cœnospecies *Phleum pratense-alpinum* have been further studied with a view to the production of agricultural varieties suitable for pasturage. In connection with this work studies are being made of the distribution and the ecological arrangement in nature of the units comprising this cœnospecies (3). Although the *Phleum* material has yielded much useful information regarding the agricultural status of sub-specific units, yet, for various reasons, it has been found preferable in investigating the genecological principles underlying the distribution of these units in nature to employ a species whose distribution is not seriously influenced by man's activities. The intensive study of habitat races of the sea plantain has, therefore, been continued.

Problems relating to the registration of varieties of the cross fertilising crops are being examined. Investigations dealing with the stability and the botanical descriptions of such varieties are in progress with a view to the discovery of applicable criteria on which to base a scheme of registration for this difficult section of crop plants.

Progress is also being made with the breeding (selection and inbreeding) of timothy, cocksfoot, and perennial ryegrass. A variety of each of these grasses has reached the field trial stage, and a second variety of timothy has been seeded for the first time this year. Both the timothy varieties belong to the ecospecies *Phleum pratense-diploidium.*

Swedes and Turnips.

Further progress was made in the examination of breeding methods with regard to the production of true-breeding strains of swede by continued selection and by self-fertilisation under artificial isolation. Lines originating from commercial varieties were maintained and new additions made; but the segregating generations of artificial crosses provided the material from which most of the new selections were taken. Some of the longer established lines were crossed.

Genetical data on the inheritance of colour in the swede were published (1). Besides a factor, N_1, governing the appearance of purple "neck," and purple "top," which is present or absent in the common yellow-fleshed varieties, a second factor, N_2, was found which gave an identical character. Although when found N_2 was associated with the factors M_1 and M_2 governing white flesh, yet it was shown statistically that no linkage occurred between any of the four factors, *i.e.*, N_1, N_2, M_1, and M_2.

Pedigree lines were sown out in duplicated plots, with suitable controls and observed throughout the season. Certain lines were examined in replicated yield trials, wherein yield, bulb weight, dry-matter content, and, in some cases, soluble solids and sugar contents were determined. Selection on the basis of dry matter percentage and bulb weight was employed on populations of F_2 generations derived from parents of hard and soft types.

Investigations on the distribution of dry matter within the swede bulb, and on the errors involved in sampling by cores were continued, and the results so far obtained were collected and published (2).

Considerable hereditary variation in sensibility to bolting was observed in a strain of swede-like rape. These plants were grown for observation in connection with the problem of the heredity of the "bulbless bolter," a rogue of swede crops. Previous evidence had indicated that this rogue was generally a rape plant, though sometimes a hybrid of swede × rape. Not all such plants bolt, but most of the specimens sent in for examination have been "bolters," chosen probably because they were conspicuous.

The interrelations of Swede and Turnip were further examined. A few lines in the F_2 and F_3 have shown partial self-fertility to a moderate extent, and comparable with the turnip parent. Mr. D. G. Catcheside, King's College, London, is voluntarily collaborating by investigating the cytology of these *Brassicæ*. Amphydiploidy has not as yet been distinguished in the material.

Potatoes—Virus Disease Investigations.

(*Empire Marketing Fund Grant.*)

Plant Breeding Station, Corstorphine.—The work on the carbohydrate metabolism of healthy and leaf-roll potatoes conducted at this station during the summer of 1931 has now been completed

and published (7). It was found that there were marked differences shown by the diseased plants, the principal fact being that photosynthesis was much reduced, and a cyclic series of reactions was in progress in the leaf leading to a breakdown in starch to hexose, the hexose in turn was converted into sucrose and this, in turn, was converted back to starch. It was also found that in the healthy potato sucrose was the sugar of translocation, whereas in the leaf-roll plants, the sugar of translocation was hexose.

During this growing season, the physiological work was extended to an investigation of the carbohydrate metabolism of crinkle-infected potatoes and also potatoes carrying a latent virus (para-crinkle). The results are now ready for publication. In this instance, it was found that in the early stages of the disease there was no statistically significant difference between the carbohydrate variations in healthy and crinkle plants, but there was a tendency for sucrose to accumulate in the petioles, as though the channel of transport was not functioning normally. Later in the season, marked differences made their appearance and it was found that there was definite impediment to free flow of sucrose leading to an accumulation of sucrose in the lamina of the leaf. It was found, however, that the concentration of sucrose in the leaf-blade never reached a sufficiently high level to suffer condensation to starch as in leaf-roll.

It was discovered that the presence of a latent virus in a variety produced no significant difference either early or late in the growing season. The nitrogen metabolism of leaf-roll potatoes was also investigated. The analytical data have not as yet been completely examined, but it is hoped that this work will shortly be completed.

A commencement has now been made with the genetical side of the potato virus problem. A number of berries have been secured of crosses between healthy and diseased plants, and the progenies will be analysed next year.

Ainville sub-station.—During the season crops of Arran Victory and President healthy and leaf-roll infected plants were grown in the greenhouse and samples were gathered during the whole season to determine the variations in nitrogen content over a prolonged period of time. The results will be published in conjunction with the nitrogen investigations carried out at Corstorphine.

North of Scotland sub-station at Gibston, Huntly, Aberdeenshire.—The profound effect of virus diseases on the breeding qualities of potatoes is being examined in an adequately controlled series of experiments with self-fertile varieties. It has been established that the fertility of plants affected with virus diseases is considerably reduced and that seedling progenies derived from diseased parents show a significantly large proportion of degenerate seedlings as compared with progenies of healthy parents. Four types of degenerate seedlings have been distinguished, of which three types

show little vigour and only rarely produce tubers. The fourth type appears to be only a slight modification of the normal type of plant and in many cases it may become normal before the end of the growing season. The detailed effect of individual diseases is receiving attention and the investigation is to be continued with seed obtained during the year.

Seed has also been obtained from self-fertile plants of varieties which have shown resistance or susceptibility to virus diseases, resistance and susceptibility being relative terms signifying the virulence with which virus diseases produce symptoms and reduce the vigour of the plant. It is proposed to test the progenies under conditions in which infection by virus diseases may readily take place with the object of ascertaining whether any indications of Mendelian segregation appear with regard to the characters controlling susceptibility.

The nature of susceptibility in the variety Golden Wonder has been examined and the results, although not yet complete, indicate that symptom-free plants of Golden Wonder carry a principle of the nature of a latent virus, which, in conjunction with a mild mosaic, produces a virulent crinkle on Golden Wonder and certain control varieties.

Physiological investigations into the carbohydrate metabolism of normal and mosaic-infected potatoes have yielded results which will be available shortly.

Titles of papers issued during the year.

1. Davey, V. McM.: Inheritance of colour in *brassica napus*. *J. Genet.*, **25**, 2, February, 1932.
2. ————: The method of sampling swede bulbs by cores. *J. Agric. Sci.*, **22**, 4, October, 1932.
3. Gregor, J. W.: Experimental delimitation of species. A reply. *J. Bot.*, **70**, 154–5, 1932.
4. Robb, Wm.: Annual report for the year ended 31st March, 1932.
5. ————: Oat breeding: Notes on two new varieties of oats recently registered by the Department of Agriculture for Scotland. *Scott. J. Agric.*, **15**, 3, July, 1932.
6. ————: Notes on the inheritance of grain colour in certain oat hybrids. *J. Genet.*, **26**, 2, October, 1932.
7. Barton-Wright, E. C., and McBain, A. Studies in the physiology of the virus diseases of the potato: A comparison of the carbohydrate metabolism of normal with that of leaf-roll potatoes. *Trans. Roy. Soc. Edin.*, **57**, 309, 1932.

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8. PLANT BREEDING DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Oats.—Further trial results largely confirm the good impression already made by the Division's new oat variety, Stormont Arrow. This variety has now appeared in the large scale variety tests of the

past three seasons, and its value for local conditions is comparatively well proven. Supplies of seed are in great demand, in many cases from growers who have already tried the variety. A new strain, selected from the cross Potato-Sandy and expected to be useful for poorer cultural conditions, has been included in the special series of variety trials conducted in such conditions.

Flax.—The two new varieties Stormont Gossamer and Stormont Cirrus have been tested for the third season in large scale plots, but the results are not yet available. At the end of two seasons' testing, however, these varieties when compared with ordinary commercial sorts show an increased yield of retted straw per acre of approximately 10 per cent., a yield of scutched fibre increased by about 50 per cent., and an increase in the value of the produce of approximately 60 per cent. As may be inferred from this statement, the yield increase is due in the main to increased fibre content in the straw, and an improvement of quality has also been effected.

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9. NATIONAL INSTITUTE OF AGRICULTURAL BOTANY, CAMBRIDGE.

Crop Improvement Branch.

Yield trials and observation plots.—In field trials in 1931-32 there were sixteen varieties of winter wheat, eight of winter oats, four of winter barley, five of spring wheat, five of spring oats, three of spring barley, fifteen of sugar beet, seven of lucerne and seventeen of peas. Three of the wheats and two of the barleys were tested under both normal and intensive manuring. In addition 128 varieties were represented in observation plots, and besides the above crops they covered grasses, clovers, sainfoins, kales and roots. Cambridge also grew 85 stock plots to provide seed for future trials or the production of pure stocks and carried out chessboard trials of eight barleys and fifteen oats to see whether this was a practicable and economical way of eliminating less valuable varieties and so reducing the demands on the area available for field trials. The usual steps have been taken to test the quality of the varieties in trials and plots.

Once again the winter was not cold enough to test the resistance of autumn sown crops to frost. The sowing of sugar beet trials was difficult. At one centre there was a complete failure, and in some of the other trials the crops were irregular. Nevertheless the yields and sugar content were excellent. Kleinwanzleben E at Cannington actually produced 3 tons of sugar to the acre. At the end of June a heavy storm laid cereal crops all over the country, and the Institute's trials suffered with the rest. This and in some instances other causes, such as slug attacks in the early stages, led to more casualties than usual, particularly among the wheats. The winter

oat trials, however, were excellent, and provided irrefutable evidence of the strength of straw of several of the new varieties.

There is no lack of useful results in the season's work. It looks as though it will soon be possible to market one or two winter oats definitely superior to Grey Winter in several respects. One new wheat combines the stiffest of straw with good yield and quality ; another shows quality not hitherto reached in England ; and a third promises well for yield. The spring barley trials seem to contradict the belief that Spratt-Archer should be reserved for soils of medium and low fertility. Little Joss has strengthened its claim to give those who must sow spring wheat better results than such a variety as Red Marvel. Hunter River, Medanose and probably Marlborough lucerne seed have been shown to be unsuitable for England, and differences of importance have been found between stocks hailing from Provence. In the case of sugar beet, it is now possible to recommend twelve different strains, but the remarkable feature is the regularity with which Kleinwanzleben E beats all comers under almost all circumstances. There is no doubt that sugar beet strains maintain their distinctive characteristics to a much higher degree than was once supposed, and that trials to compare their merits are an important factor in establishing the beet sugar industry.

The reports of the work of the 1931–32 season will appear in forthcoming numbers of the Institute's Journal. Papers No. 3-6, 11, 13 and 15 refer to some of the work done with these crops in previous years.

Co-operation with other bodies.—Twenty-three new varieties included in the field trials came from the Cambridge Plant Breeding Institute, and three from the Welsh Plant Breeding Station. The Institute also works closely with many other organisations. In the last year it has grown seed for the Scottish Society for Research in Plant Breeding ; special oat trials have been carried out for it at Cockle Park and by the County Agricultural Organisers for Cumberland and Lancashire ; farmers have submitted to field tests some of the new peas, a spring wheat, and a winter barley, the latter in plots of five acres each on six different farms ; the frost resistance of new winter oats is being tested for the Institute by the North of Scotland College of Agriculture, and in Sweden, Germany and Holland. On a larger scale is a new series of sugar beet trials to test the differential response of varieties to several manurial treatments, financed by the beet sugar factories, planned in conjunction with the Rothamsted Experimental Station, grown at three of the Institute's sub-stations, analysed and statistically examined at Rothamsted. Two beet sugar factories in Yorkshire, Poppleton and Selby, have been helped to carry out sugar beet variety trials on the Institute's methods. The Agricultural Institute at Kirton has tested a stiff-strawed wheat and has arranged for farm tests of peas.

The most extensive scheme of co-operation in progress in the past year was the set of spring oat trials in the counties. This began with 109 centres spread over 46 counties in 1932. The reduction in the number is due to the requirements of economy. The variety which gave significantly the best results in 1931, Golden Rain II, is much less widely grown than the other varieties, and in Wales the variety popularly believed to give the best results, Record, was significantly inferior to the other three varieties, Golden Rain II, Marvellous and Victory. The trials are continuing.

The Institute has also played a very active part in the work of the Cereal Synonym Committee. The Committee's report in September, 1932, met with a universal welcome and so long as the Committee remains in being there is little risk of new synonyms gaining wide currency (16).

Seed growing.—Stocks of Little Joss wheat and Grey Winter oats were successfully sold in September, 1932. A new stock of Spratt-Archer, originating from Dr. Hunter, is on sale for the spring of 1933, and varieties which are being grown on for sale at later dates are the same barley, and Squarehead's Master, Yeoman II, Rivett, Wilhelmina and Little Joss wheats.

Official Seed Testing Station.

The Station tested 30,689 samples in the twelve months ended 31st July, 1932. This is 696 more than the largest number tested in any previous season. The number of samples from outside sources for test was 27,699, which is 837 more than ever before. The number tested for investigation of special points was 2,990, about the average for a season. Just over half of these were connected with loss of vitality in storage ; cereals and clovers were the most numerous of the other kinds studied. The modifications of certain fees introduced experimentally in August, 1931, were not widely enough known in time to have much effect on the number of samples or the income from fees ; they are being continued for at any rate another twelve months.

Special studies included the origin of imported cereals ; identification of the several species of *Bromus* which occur in grass and sainfoin seed, and of *Lychnis* in clover seed ; examination of barley and oat samples for the presence of *Helminthosporium*, and, in co-operation with the New Zealand Seed Testing Station, the germination and moisture content of shipments of Chewings Fescue seed to prevent the loss of germination power which is apt to occur during the sea voyage.

In 1932, the Station received and sowed samples from 50 fields under the wild white clover certification scheme. The Growing-On Committee met at Cambridge during the summer. The total number of these samples so far sown is 788. Some of the plots are still under consideration, but 538 fields, representing some 7,000 acres, have been passed as satisfactory in their respective grades.

Potato Trials.

Yield and maturity trials (7-9, 14).—To prevent losses from eelworm and *Rhizoctonia* fresh land was brought into use for the trials at Ormskirk in 1932, and arrangements have been made to resume occupation of four and a half acres at present let to a neighbouring farmer, in order that a rotation may be followed in which potatoes are grown on the same land only every fourth year. The precautions taken have ensured excellent crops and 1932 was no exception. It had been hoped to make further progress in studying the methods and materials available for controlling blight in yield trials, and careful plans were made, but they were brought to nought by the absence of any serious attack of the disease. The new early varieties Arran Pilot and Arran Scout were tested for early bulking against Epicure and Ninetyfold ; three stocks of Golden Wonder made another trial ; and in a third Dunbar Cavalier and a Swedish variety Birgitta, both with claims to quality, were tested against Arran Banner. The study of the effect of origin of the seed potatoes on yield and maturity was continued with Arran Banner, a variety that is gaining steadily in popularity, and the old favourite Great Scot. In both cases stocks from Scotland, Wales, Lincolnshire and the Irish Free State were used ; there was also a North Irish stock of Great Scot. A trial of the recently introduced variety Glenshee was made against Up-to-Date at the Agricultural Institute, Kirton.

There were three separate trials for the Lord Derby Gold Medal. Ballydoon and Cumnock were compared with Epicure and Majestic (lifted immature) to see if they were an improvement on existing varieties for lifting after the first earlies and before the second earlies proper are ready. Cumnock was also tested as a second early against Great Scot. Finally, two late maincrops, Doon Pearl, and A.596 (now named Arran Cairn) were tested against Arran Banner and Kerr's Pink. Gold Medals were awarded to both Doon Pearl and Arran Cairn.

Quality trials.—It is easier to determine quickly the yielding capacity of a new variety than its cooking and keeping quality. Much valuable work, however, was done under the supervision of Dr. L. H. Lampitt, in the laboratories of Messrs. J. Lyons and Co., Ltd., on the 1931 crop ; samples were supplied to Professor C. K. Tinkler, of King's College, for use in working out a method of testing blackening ; and touch was established with Mr. F. Hirst, of the Campden Research Station, with a view to discovering which varieties are best for canning.

The official immunity trials at Ormskirk.—Conditions at Ormskirk in 1932 were excellent for the infection of potatoes with wart disease, so that once again every confidence can be felt in the immunity of those new varieties which remained free from it in the field test. There were 47 entries for the first year trial and 17 for the second. Thirteen came under the exchange system from the

official stations in Northern Ireland and Scotland. There were 44 control and key plots, making 121 in all. All but six of the 77 new varieties were free from wart in the field. There were 52 entries for the susceptibility trials. All these stocks, except the controls, were tested by the indoor contact method and some also in pots. 89 specimens from the contact tests were sent to Miss Glynne at the Rothamsted Experimental Station for classification. Correspondence between indoor and outdoor results was as usual very good, but there remain a few stocks which develop true wart indoors, although it has hitherto been impossible to infect them in the field. The indoor test is already of great value in checking field results and directing attention to varieties which are likely to prove susceptible in the field, but it cannot yet be accepted as an absolute guide.

Potato synonyms (10).—That the work of the Potato Synonym Committee is still necessary is shown by the fact that the number of synonyms increased from four (or 6.3 per cent.) in 1931 to nine (or 14.3 per cent.) in 1932. On the other hand, the number of synonyms actually offered for sale to the public has been reduced from 53 in 1928 to 24 in 1932.

Other activities.—A trial at Ormskirk of a diseased stock of Arran Consul against two other stocks left little doubt of the effect of leaf-roll in depressing yield. Other work on virus diseases included plots to test whether all the sets from any one infected tuber uniformly transmitted leaf-roll; plots to provide material for testing in 1933 the susceptibility to and effects of leaf-roll in the varieties Arran Banner and King Edward; demonstration plots of Dr. Salaman's virus-free stocks at both Ormskirk and Cambridge; and the control of virus disease by the continuous selection of immature healthy potato plants at Ormskirk.

An extensive collection of the principal established varieties and a few miscellaneous stocks, together with the recently listed immunes, numbering 94 in all, was a feature of the trial ground at Ormskirk. These plots are of use not only to the Potato Synonym Committee and general visitors, but also to the Horticultural Inspectors of the Ministry of Agriculture, who receive a course of instruction every summer at the Potato Testing Station.

Titles of papers issued during the year.

1. *Twelfth Annual Report.*
2. Parker, W. H.: The methods employed in variety trials by the National Institute of Agricultural Botany. *J.N.I.A.B.*, **3**, 1, 1931.
3. Armstrong, S. F.: Trials of autumn sown wheats, 1928–31. *Ibid.*, **3**, 1, 1931.
4. Humphries, Sir Albert, Clover, J. P., and Humphries, S.: The quality of certain home-grown wheats harvested in 1928–29. *Ibid.*, **3**, 1, 1931.
5. Humphries, Sir Albert, Humphries, S., and Read, L. H.: The quality for breadmaking purposes of wheats harvested in 1930. *Ibid.*, **3**, 1, 1931.

6. Armstrong, S. F.: Sugar beet variety trials, 1930 (with Appendix by Parker, W. H.). *Ibid.*, **3**, 1, 1931.
7. Parker, W. H.: Potato variety trials, 1928–30. *Ibid.*, **3**, 1, 1931.
8. Lord Derby gold medal potato trials, 1930. *Ibid.*, **3**, 1, 1931.
9. Parker, W. H.: Manuring of early potatoes. *Ibid.*, **3**, 1, 1931.
10. Report of the Potato Synonym Committee, 1930. *Ibid.*, **3**, 1,1931.
11. Parker, W. H.: Lucerne trials, 1925–30. *Ibid.*, **3**, 1, 1931.
12. Engledow, F. L.: The policy of the institute. *Ibid.*, **3**, 1, 1931.
Farmers' Leaflets.
13. No. 2. Varieties of cereals for spring sowing. Revised edition, January, 1932.
14. No. 3. Varieties of potatoes. Revised edition, February, 1932.
15. No. 6. Strains of mangolds and swedes.
16. Cereal synonyms.

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10. PLANT REGISTRATION STATION, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

Potatoes.

Laboratory tests for immunity from wart disease.—In 1932, 655 varieties were subjected to test; 161 of these were found to be susceptible.

Intensive tests of infectivity by the contact inoculation method were applied to 39 new seedling varieties, which were believed to be immune under conditions of natural infection in the field. These represented varieties under final official test of immunity in England and Northern Ireland, as well as those undergoing similar test in Scotland. All of these contracted incipient infections in the laboratory, but exhibited no sign of susceptibility in the field.

Registration scheme.—Thirty-four varieties were submitted to test with a view to subsequent registration. Three of these proved to be susceptible to wart disease. Of the remainder, 15 were recommended by the Synonym Committee for extended test in 1933 along with two carried over from 1931. The two varieties in their second year of test along with one other reintroduced from 1930 were recommended for further trial in 1933. No variety was recomended for registration.

Virus diseases scheme.—Of the selection of Majestic made in 1926, one stock has remained free from mottling; 20 acres of this have been officially certified as stock seed. Of the units selected in 1928, 11 built up stocks are available, the number of varieties being eight. The corresponding figures for subsequent years are: 1929, 25 stocks of 10 varieties; 1930, 29 stocks of 15 varieties; 1931, 55 stocks of 17 varieties; and 1932, 43 stocks of 17 varieties.

The total number of farmers engaged on the work of building up healthy stocks is now 100. The total number of stocks in different stages of propagation is 173, representing 28 varieties.

The number of units selected during the past two years has approximated 3,000 in all.

Various problems arising out of the routine work of selection and building up have provided items for investigation, notably the different types of streak and the faint mottling which is a consistent characteristic of several potato varieties.

Skin Spot investigation.—This investigation is proceeding.

OATS.

Three varieties were sown out in extended trial in 1932. One of these has been discarded by its sponsors. The other two are to be subjected to further trial in 1933.

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11. CROP (AND ANIMAL HUSBANDRY) DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Grassland.—The experiment, commenced in 1929, to investigate some of the problems concerned in the improvement of grassland, is still in progress.

The rainfall was very heavy in May and June, 1931, and Plots 4 and 5 (first year seeds) were, therefore, cut for hay and yielded respectively 39 and 41 cwt. of hay per acre. The hay from both plots was of first class quality, with much more leaf than any of the other hay on the farm which had been grown from commercial strains. Botanical analyses of the cut herbage of Plots 4 and 5 were carried out by the Botanical Division.

All plots received a further dressing of phosphates as North African phosphate, at the rate of $6\frac{2}{3}$ cwt. per acre and Plots 1, 2, 4 and 5 received 2 cwt. of 30 per cent. potash salts in January, 1932. A spring dressing of nitrogen in the form of 1 cwt. sulphate of ammonia was applied to Plots 1, 4 and 5 at the end of February, 1932.

From the grazing records Plot 1 (N.P.K), during the first year carried appreciably more stock than Plot 2 (P.K.) or Plot 3 (P.). In the second year, Plot 1 provided somewhat less grazing than in the first year, and its stock carrying capacity was practically the same as Plot 2. Plot 3 carried less stock than either Plot 1 or Plot 2. As Plots 4 and 5 were cut for hay, and the grazing of them only commenced with the aftermath, they cannot be compared with the others for this year.

Reclamation of bog.—Work in the reclamation of used-up bog, as described in the last report, is being continued and a further area has been brought under cultivation. Heavy crops of potatoes have again been produced, and sold as first quality "seed." Further manurial trials were carried out, and the effect of dressings of lime

at increasing rates was also examined (see page 30 under Chemical Division report).

Preliminary trials have been commenced to study the growth of other crops on bog, and plots of oats, various grasses and clovers, cabbages, carrots, parsnips, celery, etc., were grown.

Drainage.—While much of the land in Northern Ireland, as elsewhere, is in urgent need of drainage, little of this work is at present being carried out owing to its very heavy cost. A close watch has been kept on developments in the way of drainage machinery, and a machine was recently purchased which is capable of cutting a trench of from 24 in. to 30 in. deep, at a reasonable speed. The machine is pulled forward by means of a winch and rope attached to a tractor. Some 50 acres have been drained by the machine, which performs its work efficiently, rapidly, and at a cost very materially below that of hand labour.

An experiment is also being carried out in the use of triangular conduits made of beechwood to replace land tiles and so further reduce the cost.

Records of the cost, time taken, and labour involved are being kept.

Crop drying.—A crop drying machine, using hot air from a coke furnace, has been erected at the Research Farm and preliminary trials were carried out during the summer of 1932. A small area of a field, ready to be cut for hay, was cut in the morning, passed through the drying machine, and stacked in the hay-shed the same day. While the machine can dry grass efficiently there are points about the technique to be employed to obtain a "commercial output," which require further investigation. This work is being continued.

Cost accounts.—The cost accounts have been continued during the year at the Agricultural Research Institute farm at Hillsborough, the fourth year of the accounts being thus completed. As before, the accounts have been most useful in providing costs and other data regarding the farm, in connection with the experiments carried out as well as for management, advisory and teaching work.

C.

HORTICULTURE
and
GLASSHOUSE CROPS.

12. LONG ASHTON FRUIT RESEARCH STATION. BRISTOL UNIVERSITY.

FRUIT CULTURE.

I.—Plant Nutrition.

(*a*) *Rootstock problems.*

Field experiments.—Routine observations were continued on the trial plots of apple trees on Long Ashton selected layered stocks and on graded seedling stocks. The trees of Worcester Pearmain and James Grieve in the bush trial at Long Ashton are now cropping, but no standard trees at any centre have yet borne fruit. The influences of the various stocks, previously reported, continue to be notable.

Additional supplementary plots have been established at county centres, as follows :

Dymock, Glos., and Bromham, Wilts.—Bramley's Seedling, standards ; Whimple, Devon—Worcester Pearmain, standards ; Elburton, Devon—Worcester Pearmain, bushes. Further plantings of standard Bramleys have been arranged in Somerset and Monmouth.

Measurements of height and spread and girth of trunk were continued in the rootstock trial plot on the varieties Lane's Prince Albert, Worcester Pearmain and Bramley's Seedling worked on the various Malling rootstocks. The plot has been under grass culture since 1929, to check the growth, but, in spite of this, it has been found necessary to arrange for the removal of alternate trees of Bramley's Seedling in the block of this variety. The data collected for the early years of the plot have been analysed and a report will shortly appear.

It may be said that the results generally confirm those obtained at East Malling, though several differences appear between the two centres which are possibly due to differences in environmental conditions. In particular, the performance of No. 9 stock has been similar in its behaviour to the East Malling trials, but certain of the stocks of intermediate vigour such as Nos. 1 and 2, have shown anomalous features at Long Ashton, producing large trees.

On the plum rootstock plot, poor results, accompanied by high mortality of trees, have been obtained with the rootstocks Common Plum and St. Julien. Pond's Seedling is the only variety up to the present to yield good growth on St. Julien. Myrobolan B. has given the most consistent good results, whilst certain other stocks have produced good trees with particular varieties, viz., Victoria on Brompton ; Yellow Pershore, Purple Pershore and Monarch on Yellow Pershore ; and Monarch and Blaisdon Red on Blaisdon Red.

Laboratory work.—The trees of Lane's Prince Albert and Worcester Pearmain on the apple root-stock plot, have been used in an investigation to determine some of the relationships between root-

stock effect, as measured by vigour of the scion, and the chemical composition of terminal shoots of the trees. The data suggest that root-stock influence is related to chemical composition and that it can be modified by nutritional conditions. The semi-dwarfing Malling stocks—Nos. 2, 5 and 7—appeared specially influenced by potash level in nutrition and No. 5 also seemed to yield a " high " nitrogen plant ; No. 4 was associated with low calcium content in the scion ; and the pronounced dwarfing tendencies of No. 9 were not associated with deficiencies of any of the particular nutrient elements examined.

The results of these studies are to be considered in connection with parallel investigations on trees at other experimental centres where comparable data have been examined.

(*b*) *Factors determining the relation of growth and fruit bud formation.*

The respective activities of root, shoot, and leaf are intimately concerned with the processes of vegetative growth and fruit bud formation. The following sections have direct bearing on these subjects.

Stock and scion relationships.—The relationships which exist between leaf area and internode length have been examined in the case of the variety Worcester Pearmain on the rootstocks, Malling Nos. 1, 4, 7, 10, 12, and Long Ashton O.F.5 (1). Internode length was found to be shortest on trees on No. 9 stock, which also produced the largest ratio, leaf area : internode.

Trees on No. 4 rootstock had shoots characterised by the falling off of internode length very early in the season. No. 1 rootstock appeared to induce the largest leaf size whilst the very vigorous stocks produced shoots with long internodes and relatively small leaves. The ratio, mean leaf area : mean internode length, showed a positive correlation with the degree of precocity induced by the rootstocks.

Further data were collected in the experiment in which the possibility of stimulating vegetative growth by rootstocks is under examination. Two seasons' results of the performance of the trees in the nursery are now to hand, and these are undergoing analysis. The trees have been headworked to the scion varieties Worcester Pearmain and Cox's Orange Pippin, and the experiment will be continued under plantation conditions.

The varieties Winesap, Tetofsky, Delicious and Whitney, when used as scions and bench-grafted on to seedling roots, have been shown to exercise pronounced effects on root morphology. Records continue to be taken of the effects of these scions on root form and vigour of growth, and the results are being applied to problems of building trees of standardised vigour. Bench-grafting is also being applied to the raising of standard trees and the use of this method promises to shorten the nursery period for this type of tree.

Comprehensive series of experiments are in progress in an endeavour to elucidate the nature and location of rootstock influence, special attention being given to the part played by the "stem piece" of the rootstock. Bush trees of the variety Worcester Pearmain, with rootstocks of miscellaneous seedlings, stem-worked and bench-grafted, and of Malling Nos. 2, 9, 13, stem-worked, and with intermediate "stem pieces" of Malling Nos. 2, 9, 13 are utilised for the greater part in the experiment, but some standard trees, which will be eventually worked to Bramley's Seedling, on Malling Nos. 2 and 13 rootstocks and with various combinations of these stocks as "stem pieces" are also included. The trees are all planted in their permanent quarters and recording will proceed over several seasons. Difficulty in the initial stages of the experiment has been experienced from the dying out of buds on the variety Worcester Pearmain, a phenomenon which is very common with this variety in the district.

The seasonal cycles of nitrogenous and carbohydrate substances in apple trees.—Vegetative growth and fruiting processes have been shown in many studies to be related to optimum supplies of nitrogen and carbohydrates within the trees at certain periods during the growing season.

As a basis for studying such problems as nutritional effects of rootstocks, growth cycles, optimum times for application of manures, etc., it is thus important to secure information on the normal cycles of nitrogen and carbohydrate compounds in trees, when it can be ascertained by further studies how the various factors influence these cycles.

With these objects in mind, investigations are in progress in which the nitrogen and carbohydrate cycles of apple trees, variety Newton Wonder, are being examined. The determinations are made on two series of trees, one growing under arable conditions and the other under a system of grass culture, the latter trees being given annual dressings in March of a nitrate at 5 cwts. per acre. The determinations made are total nitrogen, and the fractions total soluble nitrogen, nitrate (if any), ammonia, acid amide, basic nitrogen, humin N, imide mon-amino acid ; and the carbohydrate fractions such as reducing sugars, sucrose, hemi-cellulose, dextrin, starch and cellulose. Lignin is also estimated.

Biennial bearing of apples.—The experiment, using the variety Early Victoria, on the thinning of blossom trusses and of fruits in the early stage and in July has been continued along the lines described in the previous report. The results of this preliminary work having shown that biennial bearing can be counteracted in part by the various thinning methods used, the experiment is to be extended to include larger units of trees, whilst the treatments will also be slightly modified. In the thinning of alternate blossom trusses in future, the operation will only be applied annually to trusses borne

on two-year-old wood, and such complete truss thinning will be carried out on other portions of the trees only in years of abnormally heavy blossoming.

Bark ringing.—Further ringing treatments were carried out on the block of Bramley trees which has been used for investigations on this subject for the past five years. The last of the trees not previously ringed were treated in 1932 and up to the time of ringing they had continued to make very vigorous growth, were of upright habit and had remained unfruitful. All trees ringed since 1928, in contrast to those not ringed, have carried good crops, vigour has been checked and the upright habit has been changed to a more spreading mode of growth. Certain of the trees previously ringed in 1928 and 1930 were again ringed in 1932, the technique of the complete ring in May, which is immediately covered with insulating tape, being adopted. The double ringing treatments at these intervals of time have produced no adverse effects on the trees and the experiments have shown in a convincing way the great value of bark ringing when properly applied as a means of bringing over-vigorous, unfruitful trees into bearing.

The observations on the effects of bark ringing on fruit quality have shown conclusively that fruits carried during the season of the ringing operation are especially susceptible to storage troubles such as Low Temperature Breakdown and Superficial Scald,whilst during 1932 it was observed that such fruits were also liable to severe damage from high temperatures during heat waves. (2, 3.)

Tree shaping and pruning.—The treatments in this experiment must be continued for several years before definite opinions can be formed on their effects. At the present stage, however, it seems evident that the varieties Cox's Orange Pippin, Emneth Early and Newton Wonder may be readily trained as " modified leader " trees.

Cover crops. — The effects of the grass + nitrate and arable systems of culture reported in previous reviews continue to be exhibited on the plot where seventeen varieties of apples are subjected to these treatments. On one section of the grass area a slight modification has been introduced into the system, the cuttings from the grass being placed under the areas of the branch spreads of the trees in the form of a mulch. One variety on the plots, Newton Wonder, is utilised for chemical investigations on the nitrogen and carbohydrate cycles in the trees under the two systems, and it is proposed to extend these investigations to studies of the nitrogen cycles in the soil areas concerned.

(*c*) *Manurial experiments.*

Pot experiments.

Two series of experiments on apple trees were continued during the year, the old experiment with Bramley's Seedling on Malling

No. 9, under treatments "complete nutrient solution" and "low nitrogen," and the new series of the same variety on Malling No. 1, with the treatments "complete nutrient," and partial deficiencies of nitrogen, potassium, calcium, magnesium and phosphorus. Special attention was given to the technique of watering, and, in the case of the experiment with the younger trees, special attention was paid to adjusting the respective nutrients in the deficiency solutions to produce desired growth characters.

Laboratory investigations.

The chemical examination of the strawberry fruits of the 1930 crop from the manurial plots at the Research Station, which was referred to in the previous report, was completed and the results have been published (4).

A close relationship between the manurial treatments given and certain chemical features was found. In particular, inorganic nitrogen was associated with high nitrogen, high total ash and relatively low sugar contents, whilst fruits from plots receiving organic nitrogen fertilisers had relatively low nitrogen and total ash, and high sugar contents; the fruits from the plots receiving no manure had the highest contents of total and reducing sugars, but not of sucrose, and contained low amounts of total ash and potash; potassium deficiency resulted in fruits of relatively high nitrogen content, and low contents of total sugars, sucrose, acid, total ash and potash; nitrogen content appeared negatively correlated with acid and total sugars; the contents of nitrogen and potassium showed a regular fall over the picking season, whilst the content of total sugars showed a well-defined increase. From the results it appears that the quality of strawberries can be significantly affected by manurial treatments commonly practised.

Similar studies are in progress with fruits of the 1932 crop, growing on experimental plots at the Botley Station, Hants, where the manurial treatments are identical with those given to the plots at Long Ashton.

Field experiments.

Experiments at Long Ashton.—In the previous report a detailed account was given of the various experiments in progress in the Station plantations, and the major results which had emerged were summarised. It is thus only necessary in the present account to record any new developments which have occurred during the season under review.

The old experiment on gooseberries was concluded and the plots have been replanted with raspberries, variety Lloyd George. The new planting of gooseberries, made as an interplant in the apple deficiency plot, has made a satisfactory start, and during the season the bushes on all plots where potassium is not given showed typical symptoms of deficiency of the element.

The deficiency strawberry plots promise to provide interesting examples of deficiencies of potassium and phosphorus respectively. The latter result is of special importance, since it is the first case in which phosphorus deficiency has been clearly exhibited in a fruit plant under field conditions. It is evident that the quality of the fruit on the various plots is greatly influenced by the manurial treatments, and it should be possible to establish the effects on quality of deficiencies of nitrogen, phosphorus and potassium.

The best flavoured berries in 1932 were on plots receiving fertilisers containing organic nitrogen ; the flavour due to dung and inorganic nitrogen was rather thin ; that from potassium deficiency was subacid and poor, lacking sugar ; whilst omission of phosphorus was associated with high acidity, poor sugar, and very unpleasant flavour.

Experiments at other centres.—Good progress continues to be made in the experiment, in collaboration with Mr. A. D. Turner, at Cannington Court Farm Institute, Somerset.

The apples, black currants and gooseberries are all well established, and significant results are already in evidence, due to potassium deficiency, with all fruits, and it can be safely asserted that the primary manurial problem of the area of the plots is deficiency of the above element. It is of interest that, in the apples, Laxton's Superb has proved to be much more highly susceptible to potassium deficiency than Worcester Pearmain, whilst of the two gooseberry varieties under experiment, Keepsake is much more susceptible than Whitesmith.

The majority of the older extension experiments were concluded during 1932, most of these relating to the effects of nitrogen in relation to cultural systems and potash manuring as a remedy for leaf scorch. The results of the manurial treatments have been very convincing and accounts of the experiments are in course of preparation.

The experiment on the production of Cox's Orange Pippin on very poor land was continued. The trees have made satisfactory progress and no point of special interest has so far arisen.

A manurial experiment was commenced on an area of apples in Sussex, where an unusual growth problem has arisen. The trees are mainly Cox's Orange Pippin on Malling No. 9 stock and the foliage shows strong purple tints which are followed by severe blotching and defoliation.

The possible parts played by potassium and magnesium are under examination.

Soil moisture experiments. (See Section XI of this report, p. 88.)

(*d*) *Leaf scorch of fruit trees.*

Pot and laboratory experiments.

Rootstock effects.—A pot experiment with apple trees, variety Cox's Orange Pippin, on Malling Nos. 1, 2, 5, and 9 rootstocks, has

been commenced to study the influence of the stocks on the scion under conditions of potassium deficiency. In order that all the trees might become well established before subjecting them to drastic potassium starvation treatment, the trees during the season all received sufficient potassium to maintain healthy growth. The order of shoot growth, due to rootstock effect, exhibited during the season was in descending order, Nos. 13, 2, 5, 1.

Chemical investigations on leaves, stems and fruits.—The analytical work was continued and it is hoped to publish full results of the investigations shortly.

Potassium status of leaf scorch soils.—Determinations of water soluble and replacable potassium in numerous cases of leaf scorch and potash manuring experiments have been made and the results are being correlated with pomological and chemical data on the trees in the various cases. An account of the investigations is in course of preparation.

Field experiments.

Investigations on the incidence of leaf scorch in the field have been continued and show the widespread need for potash manuring of fruit crops on almost all classes of soil utilised for fruit growing. A marked case was observed during the season on apples on a heavy "Weald clay."

All the older manurial experiments were concluded during the season, and the results are being prepared for publication.

A spraying experiment with 1 per cent. sulphate of potash was continued at one centre, and the results again showed that trees under field conditions can be made to react to potash in this way.

(*e*) *Leaching effects on foliage.*

Further observations were made on the relationship of weather conditions to a serious foliage breakdown, but no new point emerged.

(*f*) *Storage qualities of fruits.*

The programme of experiments was smaller than usual as the season was the final one of the period for which the initial grant was made. Special attention was given to the storage qualities of plums from heavy and light soils of the Evesham-Pershore area, whilst experiments with apples were continued with samples from centres where it is proposed to follow the effects of special treatments over a number of seasons. The analysis of the data already to hand was continued and it was possible to publish three papers on the subjects of maturity of fruits (5, 6, 7), and the influence of the position of the fruit on the cluster on storage and chemical properties (8). (See further Section XII of this report, p. 88.)

(*g*) *Canning qualities and chemical composition of raspberry varieties.*

Canning tests were carried out on 16 varieties of raspberries growing on experimental plots at Long Ashton and chemical determinations made in an attempt to establish relationships between canning qualities and chemical features.

Canning quality did not appear to be correlated with total nitrogen, total sugars, reducing sugars, sucrose, acidity, or soluble pectin.

II.—Surveys of Fruit Soils.

A detailed survey of the soils and fruit of the areas utilised for intensive fruit and market garden culture around Evesham, Pershore and Cheltenham has been completed, and a full report on the work is in course of preparation. On the soil side, the soils of an area of approximately 100 square miles have been mapped in detail on a profile basis, whilst the surface texture over this area has also been determined. Seventeen soil series have been recognised and these have been described and their chemical features determined.

In the pomological investigations, the growth features of the various fruit plants have been examined in relation to the different soil series which have been recognised and close correlations between series and tree growth have been established in certain cases. The results indicate that the survey will provide a sound basis for advisory work relating to fruit problems in the areas concerned.

III.—Investigations on Soft Fruits.

(*a*) *Strawberries.*

Cultural problems.—In addition to the nutritional investigations (see Section I (*c*) of this report, p. 73), a major section of the work on strawberries during the past two or three seasons (9) has been carried out with the object of raising stocks of vigorous plants, especially of the variety Royal Sovereign. This has been done by careful selection among plants growing under favourable cultural conditions. Experience gained during the investigations has shown that the most satisfactory varieties to plant for commercial purposes at the present time are Royal Sovereign, Oberschlesien, and Tardive de Leopold. The variety Sir Joseph Paxton has proved difficult to establish under many conditions, and does not thrive on the Station plots, even when stocks of high repute are used.

The following points have been selected for study during the next few seasons :—

(i) The effect of size grading of runners on vigour and crop yields.

(ii) The effect of age of parent plants.

(iii) The propagation of selected clone plants of Royal Sovereign. (A possible rogue or sport is under test).
(iv) Further strain trials.
(v) Pollination problems of the varieties Oberschlesien and Tardive de Leopold under field conditions.

(*b*) *Raspberries.*

Cultural problems.—In the previous report an account was given of the results obtained in the variety trials with raspberries. A further year's records were obtained which support the previous conclusions, and the experiment has been terminated in order to prepare for a further stage in the work. Attention is being given to the raising of "mosaic free" stocks in order to obtain supplies of material for trials in which cultural practices will be tested. The primary object of these trials is to discover how the performance of varieties is influenced by practices such as cane tipping, thinning of canes, etc., in order that the best systems may be evolved for the various varieties.

Attention will continue to be given to the qualities of fruits for particular purposes, such as canning, dessert and culinary uses.

Variety classification.—In connection with the raspberry variety trials which have just been completed, attention has been given to the question of a suitable method of variety identification, and a key for this purpose is now nearing completion.

(*c*) *Black currants.*

Pruning.—The pruning experiment on the varieties Boskoop, Baldwin, Edina and Seabrook was continued. The hard pruned bushes produce fruits of superior quality to those which receive light pruning, but the crops from the latter bushes are slightly heavier.

(*d*) *Red currants.*

Variety classification.—A key for the identification of varieties has been prepared (10).

Pruning.—Special attention is given to pruning methods for particular varieties, especially in certain cases where poor yields have been obtained when normal practices have been followed. Pruning methods are being shown greatly to affect yields in certain cases.

(*e*) *Gooseberries.*

Variety classification.—The work has been continued on approximately 100 varieties in the Station collection.

Variety trials.—The trials with varieties for early green picking and dessert purposes were continued. Great trouble has been experienced with certain sorts from the blowing out of new shoots

during the summer, and summer pruning treatments have been tried to prevent this type of damage. Comparative merits of varieties cannot be discussed at the present stage.

IV.—Fruit Breeding.

A résumé of investigations on fruit breeding at Long Ashton has been prepared (11).

The crops on the seedling top-fruits were poor and no new point emerged. Cropping records on selected black currant seedlings are now available for three seasons, and these show that several of the seedlings have commercial value. One raspberry seedling appears of high promise. A further family of 400 raspberry seedlings, as the result of a cross between Viking and Preussen, has been obtained. The selected blackberry varieties continue to compare favourably with the best commercial sorts. No new strawberries of commercial worth have as yet been forthcoming from the trials.

Small quantities of material suitable for propagating purposes of the best selected seedling varieties of apple, pear, plum and blackberry have been supplied to nurserymen and fruit growers under the Stations' seedling distribution scheme, which was launched a year ago. The scheme is becoming more widely known and the applications for material are increasing. It has been decided to distribute two varieties of black currant, which, under Long Ashton conditions, have given better crops than Boskoop and Baldwin respectively, which fruit at the same times as the seedlings.

V.—Control of Pests and Diseases.

(*a*) *Reversion disease and big bud of black currants.*

The field experiment in which the incidence and spread of these two diseases are under investigation was continued. Big bud, prior to 1932, was practically absent from the plot, but during the season it made its appearance on several bushes, in every case the infested bush being a " revert." The gradual spread of reversion was maintained, but there is still no evidence that the spread is associated with the arranged centres of infection (12).

(*b*) *Carabid beetles attacking strawberries* (13).

Work on the life histories and bionomics of carabid beetles attacking strawberries has been concluded.

In field experiments, methods used by growers for trapping the pests have been shown to be ineffective. Full reports on the investigations will appear shortly.

(*c*) *Capsid bugs.*

Experiments under controlled conditions in the field have been carried out at Long Ashton and Evesham to determine the types of injury which may be caused on apples and pears by the capsid

bugs, *P. rugicollis*, the apple capsid, and *L. pabulinus*, the common green capsid. The following conclusions were drawn :—

(i) Both species can cause serious damage to pears and are capable of producing the type of injury termed " Lithiasis."

(ii) *L. pabulinus* is responsible for injuries to apples, and late markings on this fruit may be due to either this insect or *P. rugicollis*.

Another capsid bug, *Aetorhinus angulatus*, Fall, was shown to cause damage to fruits of " Czar " plums in a plantation in the Evesham district, and it appeared possible that this insect was responsible for injuries to young growths on the apple, variety Allington Pippin, in an orchard near Ledbury, Herefordshire.

(*d*) *The control of Byturus tomentosus on raspberry and loganberry.*

Extensive series of trials on the control of this pest, both in the adult and larval stages, were carried out on raspberries at Long Ashton and on loganberries at a centre in Worcestershire. The materials used in the trials included :—

Derris washes as soap suspensions of the powdered root and as emulsions of rape oil.

Pyrethrum emulsions at concentrations representing 0.25, 0.5, and 1.0 per cent. of flowers.

Dusts of derris and Pyrethrum.

Atomised washes of Pyrethrum and Pyrethrum combined with specially selected kerosenes.

A colloidal preparation of barium silico-fluoride.

The major results may be summarised as follows :—

The most efficient control was obtained by two applications of the derris root soap suspension used at a strength of $2\frac{1}{2}$ lb. per 100 gallons against the larvæ.

The derris emulsion was inferior in action to the soap suspension.

The results with Pyrethrum emulsions were variable and these washes were less efficient than derris washes.

Derris dusts provided fairly good control over the larvæ, but Pyrethrum dusts were unsatisfactory.

The atomised washes were less efficient than the comparable washes used in the ordinary form.

Kerosene affected the flavour of the fruits.

One application of the colloidal barium silico-fluoride preparation produced results almost as good as those from two applications of the best derris wash.

During the season a serious case of damage to raspberry flowers and fruits by the adult beetle was noted, which shows that further experiments with a view to controlling the beetle in the adult stage are necessary.

(*e*) *Apple sawfly* (*Hoplocampa testudinea*).

Experiments were carried out at three centres, in each case several washes being applied at intervals of a few days after petal fall. Worcester Pearmain was the chief variety used, but Cox's Orange Pippin, Charles Ross and King Edward VII were also employed.

The washes tested were nicotine, derris-rape oil emulsion, derris suspension in soap, colloidal lead arsenate, Pyrethrum emulsion.

The results with nicotine confirmed those of the previous year (14). Control was generally obtained with this wash, when applied up to 12 days after petal fall, but with the variety Worcester Pearmain the period five to eight days after petal fall appeared the critical time for successful application of the spray.

Derris emulsion gave results equal to nicotine, but derris suspension, colloidal lead arsenate, and Pyrethrum emulsion yielded results which were inferior, although showing some measure of control.

Both nicotine and colloidal lead arsenate applied seven days after petal fall failed to effect control of the pest on the variety Charles Ross, and from results such as this it appears that it will be necessary to determine optimum times of application for different varieties. In certain cases, two applications may be found necessary.

(*f*) *Red spider* (*Oligonychus ulmi, Koch*).

An excellent control of red spider on the variety Bramley's Seedling was obtained by applying a 2 per cent. white oil emulsion at the green flower stage. The spray fluid also contained lime sulphur as a scab spray.

(See also later sub-section on Mixed Sprays.)

(*g*) *Woolly aphis on nursery stock.*

Good control of woolly aphis on young nursery trees was obtained with a wash consisting of a Pyrethrum extract in a kerosene with low content of aromatic constituents. The results were superior to those obtained by the usual methylated-spirit treatment and the cost of application is less expensive.

(*h*) *Die-back in plums.*

Experiments were continued with a view to finding a rootstock which will confer resistance to die-back on the variety Burbank's Giant Prune. Trees are being raised for field tests on rootstocks of Kentish Bush, Brussels, St. Julien, Myrobolan and Pershore.

The trees previously raised on Peach stock and those headworked on Yellow Pershore have remained healthy to date.

(*i*) *Die-back in apples.*

Inoculations with the fungus associated with die-back, *Cytospora sp.*, were unsuccessful on healthy trees, but when small areas of healthy tissues were injured by burning with a blow lamp previous to inoculation, the infection proceeded rapidly down the branches.

(*j*) *Raspberry diseases.*

Mosaic.—Routine rogueing methods have been continued on the established raspberry beds at the Station. The method consists of removing the affected stool, and those adjacent on either side.

It has been clearly established that new cases arise from adjoining centres of infection. Plantations may be rogued during the first year after planting, but it is doubtful whether it is economically sound to rogue after this stage.

(*k*) *Strawberry diseases.*

Red plant disease continues to appear in a seasonal way, even in drastically " rogued " stocks and attention at present is directed towards the possible influence of climatic factors on its incidence.

Experiments laid down to investigate " Sudden Wilt " have failed to produce further information, owing to the absence of the disease from the plots.

Experiments have been continued on leaf spots and fruit rots, and, in connection with the latter, spraying experiments carried out with a view to controlling " hard rot " caused by *Septoria* (*Stagonospora*) *Fragariæ*, have shown that some measure of control can be effected by spraying the plants with Bordeaux mixture previous to flowering (15).

(*l*) *Black currant leaf spot* (*Pseudopeziza ribis*).

During the past two or three seasons serious damage by this fungus has occurred prior to harvesting the crop, and attempts have therefore been made to effect control before picking. Spraying experiments using a colloidal copper spray fluid at this time were carried out, and the amount of copper residue remaining on the fruits at harvest time was determined. The amount of copper was found to be less than 0.002 ozs. per 1 lb. of fruit. The effectiveness of the spray treatment was compared with post-picking applications of the spray and of Bordeaux mixture and a copper-lime dust. The later sprayings were found to be superior.

(*m*) *Apple and pear scab* (16).

Investigations on the processes of infection and invasion of the apple scab fungus and the subsequent reaction of the host plants were concluded and the results have been published (17). These showed that shoots provide the main source of infection for the spring onset of scab, data relating to the dissemination of spores

being collected from affected shoots of the variety Lord Suffield. The course of scab attack on the shoots of several varieties was followed.

Similar investigations are now in progress in connection with pear scab.

In field experiments, attention has been directed to the problem of spray damage on the sulphur sensitive varieties Stirling Castle and Lane's Prince Albert, trials with a colloidal copper spray, giving one pre-blossom and one post-blossom application, being carried out. A moderate control of scab was effected on Lane's Prince Albert without damage but russetting of the fruit resulted on Stirling.

A large spraying experiment was carried out on a six acre block of pears, where scab had previously been very severe (95 per cent. of scabbed fruits in 1931). An attempt was made to "clean up" the plantation in one year by a very thorough spraying programme, involving three pre-blossom washings with Bordeaux mixture (4.8.50) and three post-blossom treatments with lime sulphur at 1 in 60. Spore trapping experiments were conducted in the control area, and these showed a maximum count of 1,170 spores per square inch during the period March 23rd to April 5th. 60 per cent. of the fruits on the sprayed plot were entirely free from scab blemishes as compared with 2 per cent. on the control plot.

In experiments with combined sprays (described in a later sub-section), it was found that the efficiency of lime sulphur against scab was not reduced when incorporated in certain mixed washes designed to control certain pests in addition to the fungus.

(*n*) *Fruit rots of apples and pears.*

It has been shown that the fungus *Gloeosporium album* is the cause of a serious spot rot on the fruits of Allington Pippin, and that the fruiting bodies of the fungus may occur on the twigs at the time when the fruits are ripening.

(*o*) *Combined sprays for summer use.*

There is an urgent need at the present time for reducing the number of spray applications which are necessary to control efficiently pests and diseases of apples with the spray materials at the command of the grower, and with a view to simplifying and cheapening present procedure, attempts are thus being made to evolve combined washes.

During the past season, special attention was given to the possible production of combined sprays to control (*a*) scab and insect pests often inadequately controlled by winter washes, such as aphis, red spider, and capsid bug, and (*b*) scab and apple sawfly.

In the former case, trials were carried out with a combined paraffin oil-lime sulphur spray, the concentration of the oil varying from 5 per cent. to 2 per cent., and the lime sulphur from 3 per cent

to 1½ per cent., over the period green-bud stage to post-blossom stage. Agral S.R. was used as an emulsifying agent. No spray damage resulted and the scab control due to the lime sulphur was unimpaired, but, whereas an excellent control of red spider was obtained, the control of aphis was only fair, and the results on capsid bug were unsatisfactory.

In the sawfly trial, the wash consisted of 1½ gallons lime sulphur, 8 ozs. nicotine to 100 gallons of water, 1 lb. of Lethalate—a wetting preparation—being added. 2½ lbs. Agral I was also used in one treatment, instead of the Lethalate.

The mixture yielded a satisfactory fluid which caused no spray damage. Scab control was as efficient as with lime sulphur alone, and the degree of control of sawfly was only slightly less efficient than with an unmixed nicotine wash.

It will thus be seen that the development of these types of washes appears to afford a promising line of advance.

(*p*) *Pyrethrum products.*

It has been shown that the hydrolysis of pyrethrin extracts on keeping is negligible, deterioration in insecticidal properties being almost entirely due to absorption of oxygen, yielding non-toxic compounds only slightly soluble in petroleum ether. The amount of oxygen absorbed is in the ratio of three atoms of oxygen per one molecule of pyrethrin.

A number of compounds have been prepared whose constitutions resemble those assigned to the pyrethrins. These consist mainly of cyclopentane derivatives and esters of the chrysanthemumic acids. Tests of their insecticidal properties will be made in due course.

(*q*) *Fungicidal action of sulphur.*

The nature of the mechanism of the reaction of certain reducing substances present in living plant tissues with sulphur, leading to the continuous formation of hydrogen sulphide, has been further investigated. Evidence has been obtained indicating that in the living cell these substances, after oxidation resulting from their action with sulphur, undergo reduction again to their original form by enzyme activity, and that these reversible changes are continuous. In the case of cells which have been subjected to sufficient heat to destroy the enzymes, the reversible change does not occur and on treatment with sulphur the amount of hydrogen sulphide formed is limited in consequence.

FRUIT PRESERVATION AND PRODUCTS.

VI.—The Chemistry of Fruits.

Investigations relating to the effects of nutritional factors on the composition of fruits have been continued. A large body of data

has now been collected over a five-year period and a detailed analysis of this is in progress. (See Section XIII of this report, p. 89.)

VII.—The Physiology of Fruits.

The main points which continue to receive attention are as follows :—

(i) The effects of cultural treatments on maturation processes. In these investigations, growth features and chemical changes are studied during the growth period in the orchard, and the storage and chemical histories are followed subsequent to picking.

(ii) Effect of position of the fruit on the cluster on fruit quality. The method of attack is similar to that followed under (i).

(iii) The normal course of development of the apple on the tree. (See Section XIV of this report, p. 89.)

VIII.—Cider Investigations.

Cider and perry competitions (18).—These competitions were continued. There were 82 entries spread over six classes. The outstanding features were the general excellence of the Kingston Black entries and the unusually interesting character of the " sweet " samples.

The value of Jersey apples for cidermaking.—Three varieties of apples from Jersey were tested for vintage qualities. Bellfield was considered of average quality for blending purposes, whilst Romeril and Bretagne showed useful qualities as " sweet " ciders.

Trial cider orchards.—Nine varieties of apples were tested from trial orchards in Somerset. Brown Snout and Hereford Redstreak yielded ciders of conspicuous flavour. Of the single varieties tested from the Station trial orchard, Dufflin and Dymock Red produced excellent ciders, whilst Never Blight, Knotted Kernel, Chisel Jersey and Harry Masters' Jersey all yielded products of good quality.

The resistance of metals to cider.—These tests were continued. A nickel-chromium steel was found to be practically unaffected by prolonged action of cider. Acid resisting bronzes and austenitic cast irons are now under test.

Estimation of volatile acids in ciders.—Various methods proposed for this determination have been examined. It was found that the official English method gave higher values than the French (Duclaux) procedure, and that micro methods yielded results even lower than the French.

Development of volatile acidity in ciders.—Changes in volatile acidity have been followed under various conditions of cider manufacture. In casks, a gradual increase was observed, usually ranging from 0.03 per cent. immediately after pressing to 0.08 per cent.—

0.17 per cent. after a storage period of six months. The change was greatly affected by treatments to the casks; special cask linings producing notable reductions. The increases recorded in bottled ciders were much smaller than in casks, whilst reductions were also effected by storage at low temperatures.

Identification of volatile acids in ciders.—The volatile acids have been shown to consist largely of acetic acid with varying amounts of formic, caproic and caprylic acids.

The astringent principles of cider apples.—Investigations on this problem have been commenced. An astringent substance has been isolated from a bittersweet apple juice and is now under examination.

Gelatinous deposit in perries.—Further work to determine the chemical nature of the deposit has shown the presence of pectic substance and a hemicellulose-lignin complex. The character of the deposit appears similar to that of deposits obtained by American workers from the action of enzymes on apple and grape juices.

The addition of water to pomace and to fresh and fermenting juices.—Since, under the National Mark Scheme for cider, the addition of a sugar syrup within certain limitations as to the proportion of syrup to pure apple juice is permissible, provided that the original gravity of the juice is not reduced below 1.040, various questions have arisen as to the most appropriate method and time of incorporating the sugar and water with the pure juice. Preliminary experiments on this subject have been made and the results therefrom have led to further investigations of a more critical character being arranged for the 1932 vintage.

IX.—Fruit Products.

Preparation of fruit syrups.—Syrups have been prepared by various methods from the following fruits: strawberries, raspberries, loganberries, blackberries, black currants, red currants and plums. The products will be tested for quality in due course.

Preparation of fruit concentrates.—Concentrates from the above-named fruits were prepared under conditions of high vacuum at a low temperature.

Preparation of fruit wines.—Wines were made from the above fruits and also from gooseberries and rhubarb. The products include light, dry wines and heavy, sweet dessert types. A special Portuguese wine yeast was employed in the fermentation processes.

Clarification of fruit juices by enzymes.—A pectin-decomposing enzyme has been successfully used as a means of facilitating filtration of fruit juices. Juices of high pectin content were readily filtered to a bright condition, by the use of the enzyme, 48 hours after pressing. The effects of removal of the pectin, especially in connection with pasteurisation processes, are under examination.

Sterilisation of fruit juices by the Seitz filter.—It was found possible to obtain brilliantly clear, sterile juices by means of the Seitz filter.

Non-alcholic apple juice.—Non-alcholic juices have been prepared by two methods, viz. :—

(i) Storing the fresh juice at 0° C. for six weeks, with subsequent carbonation and filtration through pulp and a Seitz filter.

(ii) Storing in a metal vessel under a pressure of 120 lbs. per square inch of carbon dioxide.

Excellent products have been prepared by the former method from juices of Kingston Black and Woodbine and these have remained in good condition for 10 months.

Preservation of plums with sulphur dioxide.—Plums were preserved with SO_2 on a commercial scale using two methods:—

(i) A cold process with whole fruits in SO_2 solutions containing 1000 and 2000 parts per million SO_2.

(ii) A hot process with plum pulp, using SO_2 at 3000, 1500 and 750 parts per million concentrations.

In all cases complete prevention of fermentation was effected. Samples of jam were made from the various preserved pulps and fruits, using commercial methods of manufacture, and the SO_2 contents of the finished products determined. Jams from the cold process contained 20 parts per million of SO_2 and those from the hot process pulps ranged from 150 parts per million to 80 parts per million of the preservative.

Comparative values of commercial pectins.—Three brands of pectin were tested in jam making trials with strawberries. The points considered were: quantities required to produce efficient setting ; effects on flavour ; effects in the presence of lemon juice and tartaric acid, and the keeping properties of the products.

Marmalade making.—The use of a domestic pressure cooker was tested for small scale marmalade making. The cooker greatly reduced the time necessary for cooking and the amount of added water usually required, whilst a full flavour was retained.

Canning qualities of raspberries.—Canning and bottling tests were carried out on a number of varieties from the Research Station plots, and these are being repeated in 1933.

X.—Willow Culture and the Utilisation of Willows.

Variety trials.—These were continued, further selections of seedlings being made and stocks of available seedlings further multiplied.

A plantation of cricket-bat willows was established, the main object being to compare the relative merits of long and short boled trees for timber production.

Pests and diseases.—(*a*) *Insect.*—Derris root preparation applied to willows under controlled conditions against the beetle *Phyllodecta* proved extremely toxic, resulting in 100 per cent. mortality.

The problems of the efficient wetting of willow foliage with insecticidal sprays have been further investigated. Two wetting agents, Agral I and Lethalate, were used with washes of colloidal lead arsenate. The best results were achieved with 1 lb. of Agral I or $\frac{1}{4}$ lb. of Lethalate per 100 gallons of spray fluid. Further increases in the quantities of the wetters resulted in considerable decrease in the amount of arsenate which adhered to the foliage.

(*b*) *Fungus.*—The biology of the fungus *Melampsora* has been worked out and the results of the investigation published (19). Spraying experiments were carried out with a copper-lime dust and a tar oil winter wash, but the results are not yet to hand. The tar oil spray injured opened buds and young shoots, and checked the development of the fungus at that stage. Laboratory experiments have shown that the summer spores of the fungus are not susceptible to control with sulphur, but are readily affected by copper compounds at high dilutions.

Peeling for white.—25 varieties of basket willows were forced under greenhouse conditions with a view to obtaining "early white" rods. The varieties were peelable from February 15th to March 12th, *i.e.*, six to eight weeks sooner than under field conditions.

White rods of the species *Salix purpurea* were readily produced by immersion of the rods in water immediately subsequent to peeling.

The culture of Salix alba, var. caerulea (*Cricket bat willow*) (20).—The causes of defects in cricket-bat timber such as the presence of trap bark, grain curvature and stain, have been investigated. The defects may result from improper treatment of the sets before planting, or from bark injury or methods adopted in removing side shoots during the growth of the tree.

Conjoint work in connection with the taxonomy of the cricket-bat willow in raising of hybrids was carried out with Dr. Burtt Davey of the Imperial Forestry Institute, Oxford.

FACTORS INFLUENCING THE STORAGE QUALITIES OF FRUITS (EMPIRE MARKETING BOARD GRANT).

XI.—Pot Culture Experiments.

Deficiency experiments.—The experiment with apple trees, variety Bramley's Seedling, on Malling No. 1 stock was continued. Attention during the season was specially directed to evolving a satisfactory technique for ensuring a favourable water supply to the trees and to determining the best levels at which to feed the respective deficient elements in the various deficiency series. The

latter point will require very special consideration throughout the duration of the experiment in order that the trees may be kept in a healthy condition and yet remain typical specimens of the various deficiency treatments. The problem has been most pronounced in cases of deficiencies of phosphorus and magnesium.

Soil moisture experiments.—The experiments with apples, Bramley's Seedling, and gooseberries, Keepsake, were continued as in the previous season and the usual storage tests carried out on the apple crop. The stored apples from the high soil moisture series again gave practically 100 per cent. of " bitter pit " specimens, and a fair percentage of " bitter pit " also developed in the low moisture fruits.

During the growing season of 1932, the trees were subjected to abnormally high temperatures during July and August, when heat waves occurred, and as a result of this a large amount of damage of the " cork " and " watercore " categories developed (42). These troubles have been followed by the rapid development of " bitter pit " in the apparently sound fruits which were subsequently harvested and the data suggest that the experiment in future should be carried out to include temperature effects in addition to those due to soil moisture.

The gooseberry experiment was concluded in 1932. The plants have been used for chemical determinations of ash constituents to see whether the differential moisture treatments affected the intake of nutrient elements. No significant difference in ash composition due to the treatments was found.

XII.—Storage Experiments.

In view of the special financial arrangements made to carry out an abnormally large programme of storage experiments during the previous season, only a very restricted programme was possible during the present year.

A special feature of the experiments was the examination of samples of Yellow Pershore plums from numerous centres in the Pershore-Evesham fruit area, to compare the keeping qualities of fruit from light and heavy soil areas. A similar experiment had been made in a previous season, and from the results it appears that the quality of the fruits on the two types of soil is much influenced by summer rainfall—light land plums were superior in a wet season and heavy land plums in a dry one.

The apple experiments referred to the points enumerated as under investigation in previous reports, but samples were only taken from the more important centres, which are being utilised for a period of years in order to check individual results against seasonal influences.

The main storage results which have been obtained to date were summarised in a paper read before the Horticultural Education

Association at Long Ashton in September, 1932, which will be published in the Year Book of the Association for 1932 (43).

XIII.—Chemical Investigations.

Chemical work was continued on previously stored samples, and on those utilised in storage tests from the 1931 crop, with a view to securing eventually a complete set of chemical data to consider in relation to the storage data amassed over the five year period of the investigations.

Certain aspects of the chemical data have been examined in relation to the storage results reported above (43), and in connection with physiological studies referred to in publications cited below (44, 45, 46).

XIV.—Physiological Investigations.

(*a*) *The effects of cultural treatments on maturity.*—Results of previous storage experiments have shown that the stage of ripeness at picking exercises important effects on keeping quality. In view of this fact and also that various cultural treatments affect storage behaviour, investigations have been commenced with the object of studying maturity processes and the effects of orchard factors on these processes.

Attention has been given to (*a*) the rate of softening of fruits on the tree and during storage, (*b*) the distribution and disappearance of starch in fruits during maturity, (*c*) the changes in nitrogen, acid and sugars, and (*d*) the effects of various orchard factors, such as bark ringing, grass and arable systems of culture, potassium deficiency and fruit thinning on these. An attempt has been made to explain the main differences observed in maturity associated with various orchard factors in relation to available food supplies to the fruits but the observed facts only partly fit the working hypothesis which has been formulated (44,45).

(*b*) *Effect of position of the fruit on the cluster on fruit quality.*—Experiments were carried out using Bramley's Seedling and Allington Pippin, in which terminal and lateral fruits were compared under conditions of " thinning " and " no thinning " of fruits on the trees. Storage experiments were conducted and the chemical changes in the fruits were followed over the storage period.

The main results were as follows (46) :—

(i) There was no difference in storage life between terminals and laterals under any of the experimental conditions.

(ii) Lateral fruits generally showed higher sucrose, and lost sucrose and total weight more quickly in store than terminals.

(iii) Thinning in one experiment tended to equalise sucrose in the two classes of fruits.

The investigations are being further extended.

XV.—Effect of Orchard Factors on the Vitamin Content of Apples.

This work is carried out in collaboration with Dr. S. S. Zilva, of the Lister Institute.

Previous experiments have indicated that the vitamin C content of apples is increased when the nitrigen content of the fruits is lowered, but this operation also involves the raising of the content of carbohydrates. Further experiments were carried out to determine whether the changed vitamin content is related to the " lowered nitrogen " or the " increased carbohydrate " by examining two series of fruits : (*a*) from barked ringed trees and comparable trees not ringed ; (*b*) large fruits and small fruits graded from one crop.

Owing to the illness of Dr. Zilva, the results are not yet to hand.

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19. Ogilvie, L.: Notes on the rusts of basket willows and their control. *Ibid.*, 1931.
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23. ————: The effect of storage temperature on cider—III. *Ibid.*, 1931.
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13. EAST MALLING RESEARCH STATION.

POMOLOGY.

In Relation to Tree Fruits.

(a) Rootstock investigations.

Apples.—Observations are continuing on the influence of rootstock on the wide series of varieties under trial. A further plot of Bramley's Seedling and Worcester Pearmain has been grassed down; but the immediate effect of the grass this season has not been so

marked as in a previous instance. The earlier plots to be grassed down have this year shown unmistakable signs of nitrogen deficiency and an attempt to alleviate this by a dressing of 5 cwt. per acre nitro-chalk has not proved wholly successful. However, the effect of grassing on the vigour of Bramley's Seedling, especially on the vigorous root-stocks, at this stage in their development, has not been sufficient to solve the problem of overcrowding on these plots and the question of thinning becomes of immediate importance.

Analysis of rootstock influence and the reciprocal effect of scion upon root.—It has already been reported (1930) that root-systems of two-year-old trees retained their distinctive characters when either stem-worked or piece-root-worked with Grenadier or Beauty of Bath. A further report has now been published (7) of field observations of similar trees three and four years old. Stock influence on scion, such as duration and length of stem growth, early blossoms, bud formation, percentage of blossom setting and amount and quality of fruit are exhibited whether the trees are stem-worked or root-worked. A series of these trees has been planted out for continued observation.

Trees of Lane's Prince Albert, stem-worked and root-worked on vegetatively raised stocks Nos. II, IX and XII, and on seedlings have also been planted out, half with the unions above ground level, and half with the unions below ground level, when special precautions are taken to prevent scion rooting. These will be grown as bushes and full records will be taken in order to study their behaviour in maturity.

In relation to this work, a study of the comparative anatomy of the roots and stock stems of a series of bench-grafted Lane's Prince Albert apple trees on four different stocks (Nos. IX, II, XII, and seedlings) has been initiated. A series of sections of roots, some of which had been growing above ground and some below, and also of stock stems above and below ground, have been prepared and examined microscopically. This work is being continued on further sets of trees.

Pears.—The pears on quince rootstocks A, B and C have borne good crops during the past season, the first considerable crop from Doyenne du Comice having been harvested. With regard to the other incompatible varieties of quince used as rootstocks, it has been noticeable that where trees originally on these stocks are still alive, most have proved to have established themselves in their own roots, whereas those which have not are now rapidly deteriorating.

The trial of Dr. Jules Guyot on clonal races of "free" (*P. communis*) stock has during this season produced small crops of fruit and marked differences between the various stocks are apparent. The two stocks which are outstanding in this respect are among those which have already indicated early cropping

potentialities in their blossom production. It is worthy of note that the trees on these two rootstocks have been up to the present among the most vigorous in the series.

Plums.—The series of trees in which three varieties on their own roots are compared with trees on various rootstocks are now yielding interesting results. Whereas with one variety (Victoria) the " own root " trees are considerably stronger than those on any rootstock, in the other two cases Cambridge Gage and Pershore, those on Myrobolan B. are still making the largest trees.

Peaches.—The trained trees failed to crop during the past season due, largely, to the adverse weather conditions experienced at blossoming time and to the lack of shelter for the trees. Clonal races of " common " peach are being raised from layers for testing alongside various plum rootstocks in the nursery as stocks become available.

Cherries.—(i) *Acid cherry* (*Prunus cerasus*) *scions.*—A report is in preparation on the results of the trial of Mahaleb, Mazzard and Acid cherry stocks with Morello scions.

(ii) *Sweet cherry* (*P. avium*) *scions.*—Of the three varieties in the trial of standard trees, one, Bigarreaux de Schrecken has this year been considerably affected by bacterial " die-back." The other two varieties, Early Rivers and Turkey Heart, are not affected enough to reduce the value of the trial appreciably.

The overseas acid cherry stocks " Stockton Morello " from California, and " Kentish " from New Zealand, are being prepared for propagation as rapidly as possible. As it will be some years before material is available for working, a preliminary trial is being prepared with suckers from two acid cherry stocks in the oldest Morello plantation.

Propagation.—The search for new rootstocks continues and these are being tested for ease of propagation and nursery performance. Thirty groups of seedling *Prunus*, presented by the John Innes Horticultural Institution and collected from the Caucasus, have been budded with the commercial variety Czar to see how far they would prove compatible with this variety, and of use as future plum rootstocks ; selections of these will be further tested for ease of vegetative propagation. A number of Quince seedlings received from Russia have been planted out for testing as possible improved rootstocks for pears.

The experiments on the propagation of fruit tree rootstocks by means of hardwood cuttings and root cuttings have been continued.

A very intensive experiment in the propagation of plum rootstocks from root cuttings carried out during the season in collaboration with Mr. R. C. Palmer has yielded valuable results. Of the two varieties under trial Pershore Egg was a complete failure, while varying degrees of success were obtained with Common Mussel. In this connection the importance of early planting of

large cuttings was clearly demonstrated. A joint report is in preparation.

The preparation of a series of plum trees having frameworks of a variety resistant to bacterial canker has been continued. Some twelve-year-old trees of the resistant variety, Utility, have been successfully " overworked " or " framework-grafted " on the Tasmanian method, with the varieties Czar and Victoria, and records of cropping and the incidence of disease will be taken.

Three varieties of apple " stem-builders " from Germany have been used in a nursery trial and have now made one year's growth from the bud. They will be worked with second scions of commercial English varieties.

Thirty-two twelve-year-old trees of Stirling Castle have in a preliminary attempt been " framework-budded " with Worcester Pearmain, but with little success. Further methods will be used next season.

A series of nursery technique trials have been inaugurated to test the effect of using rubber budding-strips and the desirability or otherwise of the removal of wood from the bud shield of apples. Further technique trials will be undertaken as opportunity offers.

(*b*) *Root development investigations.*

As a result of the exchange of workers arranged between Summerland, B.C., and East Malling the root study work has been continued at East Malling and the projected comparative study of fruit tree root systems under conditions of artificial irrigation in British Columbia has been carried out. A number of irrigated trees were excavated, and an improved type of root observation trench was installed at the Dominion Experimental Station, Summerland, B.C. Three similar observation trenches were installed at East Malling at the same time. Thus a similar technique is being used under these widely differing conditions.

In these trenches it is found possible to observe the root growth by means of glass windows supported against the soil (and normally protected from light). Information which is being obtained includes period, rate and position of new root growth and suberisation, and the reaction of the roots to various soil and climatic conditions. Photographs and photo-micrographs are also being taken. Root troubles are responsible for much loss and damage to fruit in British Columbia, and this method of direct observation seems likely to give valuable results. The research workers of the Summerland Experimental Station are now continuing this work at their station.

In the root excavation work at Summerland a number of young trees on seedling stocks were studied, and in some cases compared with the same varieties on Malling clonal stocks. The seedling root systems were found to differ considerably among themselves, and were markedly different from the root systems of clonal stocks.

Two larger trees were excavated, one being normal, and the other suffering from " collar-rot."

The root observation studies at East Malling have been extended. Records of period and rate of root-growth throughout the year have been obtained and correlated with shoot-growth, seasonal changes and soil temperature. The information thus obtained is of great interest in connection with the question of time of application for manures. The root stocks now being studied by observation trenches against mature trees are Numbers I, IX and XVI, covering the range from very dwarfing to very vigorous. The stocks in the observation boxes now in their second year are Numbers I, II and XIII.

The question of possible effect of light on the roots during examination is being studied. Preliminary evidence suggests that intermittent exposure to daylight for short periods does not materially affect the root growth of apples.

The problem of measurement of soil moisture conditions in the root area of the tree has received attention. A soil moisture meter giving direct reading, but over a limited range, has been developed, and a preliminary report on this is in course of preparation.

(c) Investigations in biennial bearing.

These have been initiated with apple trees and, in an attempt to analyse the causes, the removal of part of all of the fruit buds, at different stages of development, from either the whole or parts of trees already exhibiting the habit, is being carried out. Records from the rootstock, pruning, fruit thinning and manurial field trials are also being analysed from this point of view.

(d) Double-working of fruit trees.

Further data on the influence of intermediate varieties in double-worked apple and pear trees on cropping and fruit quality have this year been collected. There are indications that the intermediate may directly or indirectly influence the susceptibility of the fruit to scab.

A nursery trial of double-worked pear trees on some of the intermediate varieties showing promise in the field trials is now in the maiden stage, the stocks being Angers quince and a layered " free " pear.

(e) Investigations into the non-setting of the blossom of certain varieties of pears.

A concerted attack on this problem, from the points of view of cross-pollination, stem-ringing, pruning, and double-working has been begun this year. Stem-ringing was carried out with trees of Pitmaston Duchess just before the blossom opened. No effect was observed as a result of this operation on the setting of the blossom in the current year.

Pruning, whether by partial or severe dehorning, or by drastic spur thinning, somewhat reduced the crop of fruit, but appears to have increased the set of the blossoms remaining. The varieties concerned were Doyenne du Comice and Marie Louise.

Some trees of Doyenne du Comice have had certain branches topworked high up with scions of Glou Morceau. Although it has been claimed that an improved set of blossom has sometimes been obtained by this process in the first year, the results in this case are so far inconclusive.

A number of trees of Doyenne du Comice on three types of Quince, subjected to differential pruning treatments, were self pollinated and pollinated with Glou Morceau. Moderate sets of fruit were obtained by the use of pollen of Glou Morceau but Comice was found to be almost completely self-sterile under the conditions of this experiment.

(*f*) *Pruning.*

Apples.—The first year's results in the trial of dehorning and spur thinning are encouraging enough to warrant their continuance and possibly extension. Both processes have materially increased fruit size. Observations are being extended to their effect on fruit-bud formation and regularity of bearing.

Pears.—Further crops have been harvested from the older series of pears under differential pruning treatments. The younger series which is now four years old, will come under different winter pruning treatments for the first time during the coming season.

A statistically planned experiment on the effect of three different methods of pruning on growth and cropping of nine varieties of pear grown as cordons on Quince A was commenced this year. The trees were planted out as maidens in February. The pruning methods under trial are winter leader-pruning combined with winter spur-pruning, winter leader-pruning combined with hard summer spurring, and late spring leader-pruning with winter spurring.

Cherries.—The oldest Morello plantation having become somewhat overcrowded, alternate trees have been severely dehorned. The crop of the dehorned trees, as was to be expected, has in the first year been negligible. Growth, however, has been good, and there is every reason to think that this method will be a satisfactory solution of the overcrowding problem. Observations are being made on quality as well as quantity of fruit.

(*g*) *Fruit thinning.*

Plums.—Owing to the variable crop no opportunity occurred for carrying out the further experiments referred to in the last report. This, however, will be done as soon as opportunity offers.

Apples.—The experiment started in 1927 on young trees of dessert varieties has been continued. Other experiments have been

commenced in two cooking varieties—" Grenadier " and " Early Victoria."

(*h*) *Manuring.*

Apples.—The outstanding point of interest during the past season has been the very marked and comparatively rapid response to potash applications of the trees on both the apple manurial trials in progress.

The twelve-year-old Bramley's Seedling and Worcester Pearmain trees, previously unmanured for ten years, have in two seasons responded to a marked extent in growth, size and quality of fruit, to heavy applications of sulphate of potash.

In the younger and more extensive trial of Cox's Orange Pippin and Beauty of Bath, on four representative rootstocks, now two years *in situ*, the previous " running-out " of the land by growing thereon successive crops of wheat and oats without manuring has resulted in abundant leaf scorch in the present season.

This trouble, however, has been so much less on the plots receiving potash as to be of little importance, with the result that these plots have made much more growth.

Further indications of a varying response to manuring by trees on different rootstocks are bearing out the findings on the earlier trial.

(*i*) *Variety collections and trials.*

The observations made on the apple collections over a number of years have been reviewed during the year.

Most of those varieties which are worthy of retention for further trial, breeding purposes, or on account of particular peculiarities, have been worked on very dwarfing apple stock (IX) and transferred to the cordon " Library."

About 80 varieties in the original apple collection are now 11 years old. It is proposed to overwork such of those varieties as have proved poor croppers or are otherwise unsuitable.

Records are being continued on the cordon trees.

(*j*) *Fruit breeding.*

Rootstocks.—The work of raising seedling apple rootstocks from crosses between the Malling series of Paradise stocks and varieties immune to woolly aphis, with the object of combining immunity to this pest with the desirable qualities of the Paradise series, has been continued. The closest collaboration has been maintained, with the John Innes Horticultural Institution, while the Entomological Section have again been responsible for the testing of the seedlings. During the past season approximately 300 seedlings were raised at East Malling, and approximately 300 at the John Innes Institution, and passed through the infection test ; while about 1,000 seedlings should be available during the coming season.

In addition to direct crosses between various members of the Paradise series, and Northern Spy, certain of the immune seedlings have been crossed among themselves, and back-crossed on to Northern Spy. Records of woodgrowth, blossoms and fruits are being taken upon one series of selected immune rootstocks budded with Lane's Prince Albert and additional series are in course of preparation for further more extensive trials.

A number of families of seedlings from crosses between the Paradise stocks, stooled during the winter of 1931-32, gave their first crop of stocks during the present winter. Rooting was, in most cases, good, and a number of the more promising individuals have been selected for further propagation. Careful records upon these seedlings have been kept throughout and some useful information has been obtained on their botany and genetics. The data will form the subject of a paper, now in course of preparation. A few of these families will be worked in their entirety, with Lane's Prince Albert to provide information on the inheritance of their influence on the scion. A number of further families were raised during the past season. Records have been continued on trees of Lane's Prince Albert worked on selected rootstocks of VIII, X, IX raised at Merton in 1924. Seedlings of apples and pears, raised from seed collected in Russia and the Caucasus, will be planted out during the present winter to test their worth as possible new rootstocks.

Scion varieties and shortening of the "juvenile period."—During the past year several crosses between apple varieties were made with the object of producing new varieties of good quality and extended season. A few crosses were also designed to shed light on the genetics of fruit colour in the apple. A large number of seedlings worked on rootstocks IX and XII were planted out in cordon rows during the past winter, as a preliminary trial, to test the effect of rootstocks in hastening the fruiting of seedling apples. A series of 12 seedlings, layered during the past winter to provide material for a larger trial, have given their first crop of layers during the present season. They will be left for one more season before the required material is available from them. A seventeen-year-old tree of Lane's Prince Albert was overworked with scions from 5 seedlings to see how far the adult " mother " will induce earlier fruiting in the scions. All the grafts were successful and have made very vigorous growth during the past season. About 50 seedlings, now two years old, are being grown in pots in the greenhouse to see how far the restriction of root development due to pot culture may hasten fruiting. A few crosses between pear varieties, designed to produce new varieties of high quality and extended season, have been made and a number of seedlings, raised during 1931, are ready for planting out, as cordons, this winter. Several families of apple and pear seedlings, obtained as seed from Russia, will be planted out in cordon rows during this winter for testing as possible new varieties.

In an endeavour to improve the fertility of the Utility plum, flowers were pollinated with pollen from six varieties of plum. Considerable differences were found to exist in the compatibility of the different varieties. During the coming season the self- and cross-fertility of the different forms of St. Julien and Black Damas will be tested in elaboration of the cytological work of Moffett on these forms of Prunus.

(*k*) *Pomological aspects of spraying.*

In connection with the fungicide trials it has been found that sulphur sprays and dusts may cause injury (fruit-drop) on Cox's Orange Pippin in certain seasons. This variety is also " copper-shy." General observations have shown that several other varieties are sensitive to spray-injury. It is hoped that data will be forthcoming on the relationship between spray-injury and such factors as manuring, rootstock and weather conditions.

(*l*) *Marketing problems.*

The influence of such factors as variety, stock, pruning, thinning, cultural and manurial conditions, as heretofore, is being carefully watched in relation to market value over a series of years.

(*m*) *Artificial irrigation of apple trees.*

The early drought of 1932 offered an opportunity for testing out any possible effects of the partial irrigation methods, such as are used in certain localities overseas where rainfall may be a limiting factor to fruit development.

In this area of light spring and summer rainfall such methods might especially prove of value in increasing the size of green cooking apples required early upon the market. In June, a row of 16 trees of Early Victoria, 18 years old, with a heavy set of fruit, was irrigated by means of three plough furrows drawn out on either side of the trees. Water, equivalent to 3 inches of rain (67,866 gallons per acre), was regulated by stop-cocks down the furrows over a period of 30 hours. A control row of trees was untreated.

Soil moistures were determined on samples taken before and after irrigation. These showed an increase from 1 to 4 per cent. of moisture in the top 9 inches of soil and an 18 per cent. increase in the second 9 inches as a result of irrigation.

Examination of the weight and size of fruit has revealed no increase attributable to irrigation.

Unfortunately, the trees are a very variable series on seedling roots, though their individual histories were known for many years previous. The experiment will be elaborated as opportunity offers.

(*n*) *Kent fruit soils survey.*

The report on the survey of the Lower Greensand formation has been completed and is now being prepared for the press.

Meanwhile a survey of a part of the Hastings Beds formation, also known as the High Weald, has been undertaken in conjunction with Wye College. The new area includes the parishes of Cranbrook, Goudhurst, Horsmonden and Brenchley. Some 1,500 acres of fruit have already been surveyed in detail, comprising 55 farms, of which the large majority had fruit areas of less than 50 acres.

Of the total acreage surveyed, about one-tenth was found to be planted to bottom fruit, the remainder being mainly grass apple orchards originally planted in hops.

Profiting by the experience gained on the previous survey and by the comparatively straightforward nature of the soil series on the new area, both the pomological and soil sections have made rapid progress. Owing, moreover, to the extremely local distribution of the more important soil series, the correlation work has proved surprisingly easy and already, as a result of the joint investigations on soil and tree growth on the High Weald, valuable information is available with regard to the selection of the most economic sites for fruit-planting in the area already surveyed.

(*o*) *Walnuts.*

Propagation.—Vegetative propagation of clonal rootstocks is proceeding by the layering method. In November, 1931, stools were opened up and the rooted layers cut off and counted, notes being taken on the type of rooting obtained in each case. As a result of these observations, in conjunction with those made in previous years, it was possible to eliminate several selections of *J. Regia* and *J. Nigra*, which have shown poor rooting for the last three years. Hybrids between *J. Regia* × *J. Californica* and *J. Nigra* × *J. Californica* have consistently rooted more freely than any other selections. Some selections of *J. Regia* and some hybrids have not yet given satisfactory rooting on the layers. This is probably due to the very strong growth made in the early life of the stools. There is reason to expect better rooting as the stools become older and the vigour of the annual shoots is reduced.

In 1932 all the layers were treated with a mixture of " spent " hops and sand in the first two earthings, to see whether freer rooting would result. On opening up the stools in November, 1932, good roots were frequently found in association with " spent " hops. This treatment will be repeated in 1933.

Layers rooted three years ago are now developing vigorous growth comparable with seedlings. Therefore it seems probable that varieties of walnuts grafted on vegetatively raised rootstocks will be as vigorous as on seedling stocks, with the added advantage of having a known history.

This year 465 grafted plants of twelve varieties that have been chosen as most suitable for this country were raised under glass. The fungus which caused heavy losses of the walnut grafts in 1930

and 1931 has been very largely controlled with 1 per cent. formalin and 91 per cent. success with first-class material was obtained in the spring.

Results this year indicate that June is the optimum month for summer grafting. Approximately the same number of grafts were put on in June, July and August, but 66 per cent. of the successes were obtained from those put on in June.

A definite programme of patch-budding in the open has been carried out this season, with a view to finding a reliable method of outdoor propagation. Eight batches of buds were put on, roughly at fortnightly intervals, between June 29th and October 19th. Several methods were tried out in each batch. Some indication as to a successful technique has been obtained, but definite results will not be available until the surviving buds break next spring. A small autumn grafting trial was also carried out in the open during September and October. Here again results will not be available until next year.

Varieties.—At the end of 1931 two representatives of each of the 64 varieties collected at this Research Station were planted out in permanent positions at East Malling, and two at Kirdford in Sussex.

At the same time sets of twelve varieties were planted up in six localities across the South of England. In addition to these experimental sets of trees, small numbers of grafted walnut trees were distributed to growers.

The dates of leafing-out of trees in the nursery were again recorded. The late-leafing habit of the twelve varieties selected for rapid propagation was confirmed.

The nutlets on older trees of named varieties growing at the Research Station were hand-pollinated and notes were made of the dimensions, sealing, flavour, etc., of the resulting nuts.

Enquiries for grafted trees have been received from South Africa, Denmark and Palestine.

Observations on established trees.—In January, 1932, graftwood for spring grafting was collected from the trees selected at the walnut competition in 1929, and from the tree at Leeds Castle.

Data were collected, as in 1931, on the question of pollination of the established trees, which have been selected as the best in the country. This information corresponded with that received last year.

In the summer, expeditions were made to the six sets of grafted trees that were planted up in the previous autumn. Records were taken on the growth and vigour of the same varieties under different conditions, and on the incidence of disease and character of the soil. Visits were also paid to the established trees selected at the walnut competition, and notes made on the general condition of the trees and the probable crops.

Oil content determination work.—In January, 1932, the percentages of oil and moisture were determined in samples of fresh nuts from the trees selected at the walnut competition in 1929. In every case the results were within 3 per cent. of those obtained last season. Therefore the outstanding quality of nuts from these trees was maintained even after the very unfavourable season of 1931.

Curing and storage trials.—Two samples of nuts were again used, (i) from one of the selected competition trees, (ii) an average sample from a local tree. After the heavy rainfall in 1931, both samples were below the average and about half the nuts had to be rejected on account of poor sealing and deficient shell formation.

After deshucking and washing, a portion of nuts from each sample was dried in the furnace room at 90 deg. until no more moisture was lost.

As a result of experiments during the last two years it was possible to eliminate several methods of storing. By doubling the strength of the bleaching solution an attempt was made to increase its fungicidal properties on the bleached nuts. This method was unsuccessful as a white deposit appeared on the nuts when dry. The fungicidal properties of salt as a storage medium was much impaired when the nuts were dipped in a saturated solution of it instead of surrounded by it in bulk. A storage medium consisting of salt mixed with an efflorescent compound is being tried out. Promising results were obtained by the new method of dipping nuts in melted paraffin wax before storing. Experiments are being continued in this direction.

The possibility of storing walnuts under conditions similar to that of a private cellar are being investigated, in contrast to the comparatively simple problem of keeping them fresh and free from fungi in cold store.

Diseases. (See pages 108–114.)

In Relation to the Small Fruits.

(*a*) *Nomenclature, classification and variety trials.*

A small number of bushes of the extensive range of varieties of black and red currant collected during the past twenty years is being maintained as a reference " library " as in the case of apples and pears. These are used for identification and breeding work as occasion arises.

The variety trials of black currants have been continued. The high cropping performance of the new seedlings raised at East Malling has been maintained and one of these is being planted, together with Baldwin, on a commercial scale during the coming season.

Work has begun on the classification of the mixed material grown under the group name of " loganberry." Data collected

during the year fully illustrate the statement of Crane and Darlington in *Genetica*, IX, 1927, that "In England the loganberry is not a clone; this accounts not only for its various appearance, but also perhaps for the conflicting reports of its genetic properties. After its introduction it was frequently raised from seeds. The seedlings obtained were not uniform and the plants distributed varied in vigour and many other characters." Widely varying types have been identified in commercial "loganberry" plantations, including the form generally known as Phenomenal Berry. In accordance with the usual East Malling practice clonal races of some of these various forms are being raised and described and they will be compared pomologically.

There are indications that problems similar to that of the loganberry arise in the case of certain blackberry varieties. This is being investigated in a similar manner.

The description and preliminary trial of about a dozen of the more important varieties of blackberries and dewberries are being continued.

(b) Propagation and the establishment of clonal races.

The schemes for the propagation for distribution, through commercial channels, of clonal races free from disease have been sufficiently advanced to show that the time and trouble involved are amply repaid by the results, and that growers readily respond to the opportunity offered of obtaining clean stock. (See also Raspberry Mosaic, page 110.)

In a clone trial of strawberries all the runners from six selected parents have been planted out for trial. These six parents produced about 800 runners, whose whole life history has been recorded in detail. In two families, runners representative of different times of formation and different positions on the stolon have been used for the production of a second "generation" of plants on which similar detailed records have been taken. All the rest of the plants are being recorded individually for vigour, blossoming, cropping and disease. The first year's records are already giving valuable information with regard to selection of runners.

Work on the best methods of raising and transplanting some of the more important varieties of *Rubi* is being continued on clonal material.

(c) Planting, training, pruning, etc.

Further records have been obtained in a "uniformity" trial of strawberries, from which information of value in the planning of strawberry experiments is being gained.

Trials of "strain", time of planting and deblossoming of strawberries have been continued. Previous years' results, showing the advantage of early autumn planting both in vigour and cropping are confirmed. The deblossoming trials showed that not only were

the size of plant and production of runners increased by the removal of blossoms in the first year, but the crop in subsequent years was in most cases also materially increased. As the strain trials grow older new differences in vigour and cropping of the strains are appearing. The question of the virus disease "Yellow-edge" appears to be important in this connection, and is now being studied (see page 111).

The trial of loganberries, in which training is being studied in relation to cropping and disease factors, is yielding useful information.

(*d*) *Manuring.*

The manurial trials of raspberries have been continued this season and a report has been issued (8). The results indicate that, on this soil, with two varieties of very different habit, a proper balance between nitrogen and potash is the secret of the successful manuring of raspberries. Nitrogen may, up to a point, produce more cane by itself, but has never increased the crop except in the presence of potash. Of the kinds of potash fertiliser tried, sulphate of potash has, on the whole, proved superior to Kainit. (See also Statistics, page 105.) A further trial is in preparation.

(*e*) *Fruit breeding.*

Black currants.—A plantation of 1,000 seedlings, consisting of selected seedlings from previous trials back crossed on to one parent variety, now five years old, gave their first appreciable crop during the past year. Many of them were markedly superior in cropping to Baldwin, growing under the same conditions, and about 20 have been selected and will be propagated for further trial. The seedlings are being retained for one further year.

A block of about 1,000 bushes, consisting of crosses between the main varieties, now two years old, are being recorded in conjunction with self-pollinated families of the same varieties, in an attempt to follow out the inheritance of the botanical characters. Considerable progress has been made in elucidating these characters on a Mendelian basis.

Through the kindness of the Director of the John Innes Horticultural Institution, seed, pollen and young flowers of the black currant were subjected to X-ray treatment, during the past spring, in an attempt to induce mutations of value in the improvement of varieties. A large number of seedlings have been raised from such treated material, and will be closely studied during the coming years. A number of hybrid plants from crosses between *Ribes longeracemosum* and the black currant and between the gooseberry and the black currant have been raised. Some of these should fruit for the first time during the coming season. The trials of Wellington's selected seedlings have been continued. They were superior to Baldwin in their cropping performances here, during

the past season. They are still being propagated in quantity and, "Triple X" in particular, is becoming increasingly popular among growers.

Red currants.—No further families of red currant seedlings were raised during the year, but existing families are still being recorded for botanical and fruiting characters.

The collection of *Ribes* species has been augmented by several gifts during the year. The botany of these species is being closely studied.

Strawberries.—Two families of strawberry seedlings raised during 1931, were planted out, for cropping, during the past spring. Considerable differences were observed in their susceptibility to "Yellow-edge" disease. In collaboration with the Mycology Section, it is proposed to make further crosses during the coming season, to elucidate, if possible, the transmission and inheritance of this disease.

Raspberries.—Some six of 40 seedlings so far propagated have now been chosen for further propagation and trial.

Crosses have this year been made in the hope of producing varieties with high quality fruit and resistant to mosaic and other diseases.

(*f*) *Fruit thinning.*

Gooseberries.—Experiments have been commenced to test—(*a*) the relative value of thinning against no thinning; (*b*) the ultimate effect on the crop by removing in one case the larger and in another case the smaller berries as soon as they have attained a marketable size.

Statistics and Records.

Plot layout.—Now that a considerable amount is known concerning the variation to be expected in many fruit trees as grown at the present time, it has been possible to improve further the methods of plot layout, which are being used. In this connection the growing needs of all Sections have afforded ample scope for the trial of newer and more economical methods.

Further, increasing demands from outside have given opportunities for the arrangement of plots on many different kinds of fruit plant.

Some of the trials laid down five years ago on soft fruits have now yielded their results and the technical experience gained is of great value.

In particular, an account has been given of two manurial trials of raspberries (8). These trials have further emphasised the need for uniform material free from disease. They have also fully justified the methods used, which involved a proper distribution of replicated plots; since in one case the differences connected with

position were considerably greater than those due to the manurial effect.

During the season a number of trials involving nursery practices have been planned. Of these, one, involving five separate factors, on the propagation of plum stocks from root cuttings, has been completed and a report on the statistical and pomological aspects is in preparation.

A series of simple manurial trials on growers' plantations have been planned in collaboration with Imperial Chemical Industries and Mr. W. G. Kent.

The records of a four year uniformity trial of strawberries have been examined and a report will be issued shortly.

Technique of recording.—Investigations under this heading are continuing. Further sampling methods have been tried as opportunities have arisen.

A method for sampling the annual wood growth of spur-pruned trees has been perfected ; and the problem of a similar method for use on trees, the leaders of which are not tipped annually, is being investigated.

PHYSIOLOGY.

Vegetative propagation.

Investigations on the conditions favouring rooting in hardwood cuttings have been continued in collaboration with the Propagation Section. For the third year in succession improved rooting of various plum stocks has been secured by placing a layer of sphagnum moss under the sand of the cutting bed. A layer of spent hops proved nearly as effective as one of sphagnum. An experiment on the combined effect of a layer of hops and of shading the cutting bed with muslin during the summer months has given favourable results. The percentage of rooted cuttings obtained was greater in the shaded bed than in the control which had a layer of hops. No improvement in rooting has been secured as yet by ringing or notching or by treatment of the cuttings with dormancy-breaking substances such as ethylene chlorohydrin.

Leaf relations in apple trees.

The distribution of leaf surface.—The data obtained in 1931 from an investigation of the leaf relations of two nine-year-old apple trees (Laxton's Superb) have been analysed and the results are being published shortly. One tree was on the dwarfing No. IX stock, the other on the more vigorous No. V, and they were in different fruiting conditions. The coefficients of variability in leaf number per growth and in leaf area show that the differences between the two trees could have been proved by counting the leaves on a random sample of a few hundred growths and by measuring the area of a few hundred random leaves. When the growths were grouped, however, according to their character, into

categories such as " bearing " spurs, " non-bearing" spurs, primary shoots and secondary growths, the leaf relations were found to be widely different in various categories and much of the dissimilarity between the trees was found to arise from the proportions of growths in each category being different in the two trees. Thus the tree on No. IX had many more small-leaved bearing spurs and far fewer large-leaved primary shoots than that on No. V. In most categories, however, there were significant differences between the trees both in the number of leaves per growth and in the mean area of the leaf. To obtain an accurate estimate of the number, distribution and size of the leaves on a large tree by sampling, it will be necessary therefore to sample from each category of growth separately and to get some measure of the relative numbers of growths in each category. Work on the elaboration of a sampling technique that will fulfil these requirements is in progress.

Carbohydrate relations.—Work on another aspect of leaf relations has been in progress this season ; quantitative estimations have been begun of the carbohydrates in the leaves of an apple variety worked respectively on a dwarfing and on a very vigorous rootstock, to determine whether the efficiency of the leaves, as carbon fixing organs, is influenced by the rootstock upon which it has been worked.

Growth.

Seasonal course of root and shoot development in apple stocks.—The investigation into the course of growth during the year in the apple stock No. XIII, on which a preliminary report was published in 1931, was brought to a close in May, when the trees had completed their second year's growth. The data will be analysed before further work on this line is initiated.

Effect of scion on root.—In the case of work previously reported which showed that the different rootstocks retain their varietal characters irrespective of the influence of scion variety, indications were obtained that the percentage of fibre was dependent in some degree upon the size of the root system. In collaboration with the Pomological Section, a batch of nearly 400 two-year-old trees of Grenadier, exhibiting a wide range of size of root system, has been lifted and analysed to investigate this point more fully, and the records are now being examined.

Records have been made of the leaf surface and stem lengths developed during the maiden year by the trees of the two apple varieties, Beauty of Bath and Grenadier, which were worked last year for an investigation of the causes of the marked difference in the relative amount of root produced by stocks worked respectively with these two varieties. The trees will be planted out and their stem and leaf development recorded for two or three years. They will then be lifted and the relative amounts of root, leaf and stem in trees of the two varieties determined.

BIOCHEMISTRY.

Mutual influence of rootstock and scion.

Ash analysis.—This work has been carried on along the lines already indicated in previous reports.

Functions of the elementary constituents.—Methods have been evolved for introducing solutions directly into fruit trees. Not only may the leaves of a tree be almost completely permeated, but separate branches of a single tree may each be permeated with a substance in solution without contamination by the substances introduced into other branches. Such branches may vary from current year's shoots to ones carrying one-tenth, or even more, of the foliage of a large tree. Because of their convenience dyes were used in most of the work on methods, but a few experiments in which potassium salts and sodium thiosulphate were used suggest that the general principles elucidated by the use of the selected dyes are applicable to such simple salts as artificial manures, but differences in detail are to be expected. The methods are sufficiently simple and inexpensive to be applicable to many practical problems in the plantation.

An experiment carried out on three hundred rootstocks of Type III to test further the apparent effect of sodium thiosulphate on apple mildew failed to show any such effect. In a later experiment separate shoots of a heavily infected tree which had absorbed this substance were for a time almost free from mildew, whereas an equal number of similar shoots which had absorbed water were heavily infected. The vigour of the former shoots was increased. Introduction of potassium nitrate into this same tree as a whole markedly increased its vigour.

Plum trees suffering from silver leaf or die back disease present special difficulties, but a number of heavily attacked trees have had, as a result of treatment, over ninety per cent. of their foliage permeated.

This work is now being written up for publication.

Causes of resistance to woolly aphis.— As this work has now reached the stage of requiring the almost undivided attention of at least one specialist worker it has been discontinued for the moment.

Chemical examination of apple bark.—This work also must await suitable assistance.

PLANT PATHOLOGY.

Mycology and Bacteriology.

Crown-gall—The final observations have been taken in the experiment for investigating the relative susceptibility of apple stocks to crown-gall, referred to in the last report. The results of this experiment confirm and amplify the results obtained previously (see 1930-31 report). The data are now being prepared for publication.

Preliminary experiments were carried out to test the effect of applications of sodium nitrate to apple trees artificially inoculated with the crown-gall organism. The results were irregular, for not all inoculated trees developed galls. On the whole, however, the plants which received sodium nitrate produced more and larger galls than those plants which were not so treated. On some of the trees large galls developed but there was no evidence that the galls had any detrimental effect on the growth of the tree.

Brown rot diseases.

Leaf infection by Sclerotinia cinerea.—Further trials have been made in investigating the manner of leaf infection by *Sclerotinia cinerea*, in relation to wilting of shoots of plum stocks in the layered nursery rows. " Stools " have been raised in pots, and leaves of shoots were inoculated immediately before they were " earthed-up." Infection, resulting in wilting of shoots, arose only where the inoculations were made on leaves which had been injured by puncturing.

Fruit infection by Sclerotinia fructigena.—Severe outbreaks of brown rot occurred in 1931. In one instance apples were rotting in the market two or three days after they were picked. It was found that infection by *Sclerotinia fructigena* had started at the wounds left by picking the fruit away from their stalks. An account of this phenomenon has been published (22).

Bacterial diseases of fruit trees.

Bacterial canker of plum trees.—Data on the observations made on bacterial canker in plum trees since 1924 have been brought together and detailed descriptions of the symptoms of the disease have been published (10, 13, 18, 19). The diseased trees are characterized by pale foliage, the leaves usually having upturned margins. On such trees a canker appears on the stem and the trees die during the summer. The organism causing the canker has been found to infect the leaves also, and occasionally the shoots and fruit. Its cultural characteristics have been studied in detail with special reference to its relation with *Pseudomonas prunicola*, which causes a bacterial shoot wilt of plum trees.

The possible existence of the canker-producing organism in the soil has received consideration. Attempts to isolate the organism from the soil of plantations containing infected trees have so far been unsuccessful, and the direct inoculation of stems with soil has failed to produce infection.

With the object of ascertaining whether soil conditions have any effect on the pre-disposition of plum trees to bacterial canker two experiments have been planned.

(*a*) A series of pot cultures has been set up using a " complete nutrient " in sand, and various modifications of it. The trees have been subjected this year to the different

nutrient treatments ; next year it is proposed to continue the treatments and then to inoculate the trees with the bacterial canker organism.

(*b*) A series of 24 plots have been planted up with young plum trees and submitted to various manurial treatments in random distribution. They will be kept under observation for the incidence of bacterial canker in relation to the different soil conditions, and artificially inoculated if necessary.

Experiments to test whether it is possible to provide " frameworks " of resistant varieties on which to " overwork " the more valuable but susceptible varieties have been started. (See Pomology Propagation.)

Raspberry mosaic disease.

(i) *Analysis of symptoms and varietal susceptibility.*—A further grafting experiment was carried out to analyse the symptoms of mosaic as they appear on the variety Lloyd George with reference to the two distinct forms of mosaic previously identified on the variety Baumforth Seedling B. This analysis was also extended to include the important varieties Baumforth Seedling A, Maclaren's Prolific and Preussen. Compared with the results of previous experiments the percentage of successful grafts was outstandingly high. This in the first place was because the healthy plants used were in a very vigorous condition of growth due to the fact that they had been potted and grown for a complete season before the season of grafting. It was also due in part to an improved form and technique of bark-grafting which was used for the first time.

(ii) *Experiments in commercial control.*— The six special nurseries for producing Lloyd George cane free from mosaic infection (and incidentally from infection by the important cane-spot, cane-blight and spur-blight diseases) which were planted in 1931 on selected farms in Kent and Sussex, have been rigorously inspected and rogued throughout the season and have produced their first crop of reliable mosaic-free cane. Each nursery was planted with 300 special mosaic-free canes raised on the parent Research Station nursery. The labour and time involved in inspecting and roguing these nurseries has been very slight and their individual output this year (the first year of cane production) has been in the neighbourhood of 8,000 canes.

The demand for this cane and also for cane from the Research Station nurseries has greatly exceeded the supply. Applications have been received from all parts of the country, from Scotland, Ireland and from Canada. Thus the first reliable scheme for the commercial control of raspberry mosaic (in Lloyd George in the first instance) is now actively proceeding. The attitude of growers to the opportunity provided is ample proof of the need for such

schemes and there is every indication that they can be successfully and economically carried out.

Loganberry cane spot.

A further spraying trial carried out during the year has indicated (i) that the addition of a spreader does not appreciably improve the action of a spray applied at the "delayed-dormant" stage, and (ii) that the effectiveness of the control of the disease is greatly increased by the application of a spray at reduced strength at the "pre-blossom" stage. In addition, a preliminary attempt was made to combine a fungicide for the control of cane-spot with the first application of derris against the loganberry beetle. The results of this trial were sufficiently encouraging to warrant elaboration next season.

Diseases of cultivated blackberries.

As time has permitted work has been continued (*a*) on the "Blue-blotch" disease (*Septocyta ramealis*) which is responsible for a considerable reduction of the cropping of certain varieties, and (*b*) on the so-called "Reversion" disease which is associated with the widespread degeneration of the "Cut-leaf" variety. Preliminary attempts to control the former disease by spraying with Bordeaux mixture have yielded promising results.

Strawberry "Yellow-edge" disease.

A large scale transmission experiment was carried out during the season employing the grafting technique previously determined and described in a paper published during the year (12).

This experiment has finally confirmed the inferences drawn from the previous year's work, and has shown that although in the field Tarsonemid attack is commonly associated with the disease, yet a rapid degeneration of normal vigorous Royal Sovereign plants can be brought about under strictly controlled conditions solely through the agency of a transmissible virus and quite independently of direct injury caused by mites or insects.

The diagnostic symptoms of this disease, which are of an extremely ill-defined and transitory nature, have been determined in the case of several well-known varieties (Royal Sovereign in particular) and, in order to distinguish it from the analogous complex of diseases in America and from symptoms sometimes induced by direct mite injury, it is proposed to refer to the disease as strawberry "yellow-edge."

Evidence is forthcoming that this disease occurs in widespread districts and is of very grave import to the strawberry grower. Further experiments have shown that the spread of the disease under natural conditions is rapid but local in nature, and that all runners taken from plants showing symptoms of the disease are themselves infected. Infected plants ultimately and invariably become sterile

and die quite independently of any insect infestation which may be present or ensue.

The disease is closely associated with infestations of the Tarsonemid mite and experiments to ascertain whether this mite is a vector are in progress (see page 116).

Records taken during the year indicate that varieties differ considerably with regard to their susceptibility to the disease and, further, that certain " strains " of a given variety may be more susceptible than others. There is also some evidence that in a given cross between two varieties, the quality of high susceptibility to " yellow-edge " may undergo segregation (see page 117).

Attempts to propagate and maintain supplies of virus-free runners have been commenced in collaboration with the Entomology Section. A full report of the above experiments is in course of preparation.

" Fruit-russeting " and " branch-blister disease."

Increased attention to the methods employed for isolating, in pure culture, those fungus-types associated with typical disease symptoms, has made possible a more definite classification of the types from different sources No other definite stage in the life-cycle of the fungus-type tentatively referred to the form-genus *Coniothecium* commonly isolated has yet arisen in pure culture, and further numerous inoculation experiments made on pot-bound trees in spring, 1931, again failed to give conclusive results concerning parasitism.

It seems that the association of fungi with fruit-russeting and branch-blister symptoms is likely to be secondary, as a causal factor, to " tree-condition," as governed by soil-type, nutrition, cultural practice and climatic conditions. An attempt to find correlation between the distribution of disease-symptoms in the field and nutritional deficiency in the tree will be made in future work on this problem.

Fungicide trials.

Apple scab and apple mildew.—Data have been obtained for a second year in the re-planned spraying and dusting experiment on Cox's Orange Pippin. They have not been classified, but general observations clearly showed that, for the first time in the last six years at East Malling, an initial spray-application at the " green-bud " stage was really necessary for excellent scab control in 1932. This is considered to be entirely due to the exceptional spring weather, which was very favourable for spore-production and dispersal while making tree-growth unusually tardy. Post-blossom sulphur dusts gave good control where efficient pre-blossom protection had been afforded, while a half-strength Bordeaux mixture (4 : 18 : 100, made with hydrated lime) appeared safer to use, though less fungicidally-efficient, than the full-strength spray formerly

tested. Three applications of lime-sulphur, one pre- and two post-blossom, again gave very good Scab- and Mildew-control.

Spreaders.—No increase in fungicidal efficiency was shown where " Spray " gelatine at 1 lb. per 100 gallons was used as a " spreader " for lime-sulphur with lead arsenate.

Post-blossom sulphur spraying and dusting caused fruit-drop on Cox's Orange Pippin in 1932.

Pear scab.—A second year's tests (on the variety Fertility) on the lines of those initiated in 1931, provided very full data which have not yet been classified. The reduction in strength of both post-blossom lime-sulphur applications to 1 : 100 obviated spray-injury, but made the fungicidal effect of three applications in all rather less satisfactory than that of the same three applications of full-strength Bordeaux mixture (8 : 8 : 100). Colloidal sulphur was again unsatisfactory. On the whole, Bordeaux mixture appears to be much preferable to sulphur sprays in the control of this disease.

Factors affecting susceptibility to apple scab and mildew.—A large number of data on the effect of rootstock and manuring on susceptibility to scab in Bramley's Seedling and Worcester Pearmain have yet to be classified. Further data have been obtained on the effect of rootstock on scab- and mildew-infection in Cox's Orange Pippin.

Diseases of walnuts.

Walnut bacterial blight.—Bacteria isolated from leaf-spots on established walnut trees in Sussex, Surrey and Kent, have now been proved by inoculations to be parasitic.

In November, 1931, bud scales of young walnut trees were inoculated with the blight organism, as it was expected that it might overwinter in such a position. Negative results, however, were obtained when the buds grew out in the following spring.

To control walnut blight on the nursery trees, stem lesions were cut out of all trees during the winter. Three applications of Bordeaux mixture were given in the spring and summer, a few unsprayed trees being left as controls. Owing to the dry summer of 1932 very little blight occurred on sprayed or unsprayed trees.

In relation to the occurrence of the disease in England and France, an article discussing the distribution of the disease has been published (11).

A disease following grafting.—Work has been continued on the *fungus* (*Chalaropsis thielaviodes*) associated with, and believed to be the cause of failures in grafting walnuts. Its morphology and cultural characters are being compared with those of a similar fungus isolated from carrot.

In addition to being found on walnut grafts, this fungus has now been recorded on dead rooted layers at the point where they were removed from the parent stool. It was also present on the

roots of a grafted tree which had died after being planted in a permanent position.

Experiments have been carried out to test the parasitism of the fungus. Plants that were inoculated during grafting all failed to form a union, while controls remained healthy and grew out normally.

In April, 1932, tap roots of seedling walnuts were inoculated with *Chalaropsis* from walnut. The inoculated plants and controls were potted up, and examined in the autumn of 1932. In every case a positive result was obtained from those that had been inoculated.

As Chalaropsis thielaviodes has previously been recorded only as a parasite of lupins in Italy, lupin seedlings were inoculated with pure cultures of the fungus from walnut and carrot. In every case lesions resulted.

In the winter of 1931, after trying out various solutions, it was found that 1 per cent. formalin is toxic to *Chalaropsis* spores. This solution gave a good control of the fungus in the greenhouse.

A Botrytis parasitic on walnuts.—Reddish brown lesions were noticed on nursery trees during March, 1932. A *Botrytis* was isolated easily from any lesion. This fungus has since been proved by inoculations to be parasitic on walnut stems.

Other diseases.

Grey mould on apple roots.—In January, 1932, *Botrytis cinerea* was found on the roots of one-year-old bedded stocks (East Malling, No. VII). Many roots were brown and dead and these bore the fructifications and sclerotia of the fungus. Other stocks were free from this trouble and it is considered that the No. VII stocks became infected by reason of their very fibrous roots, which in the " bedded in " bundles retained an excessive amount of moisture, thus favouring attack by *Botrytis* (16).

Lilac bacteriosis.—A severe outbreak of bacteriosis in lilacs on a farm in Wiltshire has been studied, as it appears to be the first authentic record of lilac bacte osis in this country. A bacterium has been isolated from infected shoots and leaves and in preliminary tests this organism shows affinity with *Bacterium Syringæ*, which has been found to infect lilacs on the Continent and in the United States. This organism is of interest from a pomological point of view, for recent American investigations show that *B. Syringæ* is closely related to, if not identical with *B. citriputæle*, which is the cause of citrus " Blast," and with *B. cerasi*, which infects cherry trees. A brief account of the outbreak has been published (21.)

Entomology.

The control of the fruit tree red spider.

A preliminary spraying trial was carried out in the winter of 1931-32 to test the toxic properties of some petroleum washes and

tar-petroleum washes of known composition against the eggs of the fruit tree red spider.

The sprays were applied at a strength of 10 per cent. in February.

The sprays gave a measure of control varying from 40 per cent. to 80 per cent., while the percentage of mites hatching from the eggs in the absolute controls was 84. The treatments giving the better control included two containing tar oils and one consisting of a " straight " petroleum.

Tests with the more favourable of these sprays are being designed for the coming season.

The resistance of different rootstocks to woolly aphis attacks.—Some 773 apple seedlings, raised at Merton and East Malling, have been tested again during the year. Of this total some 546 Northern Spy crosses, and including No. IX and No. II selfed, raised by Mr. M. B. Crane, of the John Innes Horticultural Institution, Merton, and tested at East Malling, gave interesting results. 213 proved to be immune to aphis attack, while 40 were included in the highly resistant group. The remainder were contained in the very susceptible class. Of the Spy crosses raised and tested at East Malling 145 proved to be resistant, while 131 were placed in the susceptible group.

An outstanding feature of this year's experiments is that the number of immune and highly resistant seedlings is much greater than usual. At present there appears to be no explanation for this phenomenon.

The 19 seedlings found to be immune in the season of 1931 have been tested for the second year and the immunity characteristics hitherto exhibited have been maintained.

A number of selected immune seedlings (Spy x II), which were tested at East Malling, have been forwarded to Canada, New Zealand and South India, in order to ascertain whether the immunity characteristics will be maintained under the varying climatic conditions of those countries. The stocks are being tested purely from an entomological point of view, and at present they are not for general distribution.

Causes of immunity.—The investigations in relation to the causes of immunity, hitherto carried out in conjunction with the Biochemical Section, have been held over until such time as a full-time worker on this specialised subject can be arranged.

Woolly aphis parasite.—The woolly aphis parasites liberated in an orchard near Maidstone in 1931 survived the winter of 1931-32 and were still present in the plantation during the summer of 1932. The remains of parasitized woolly aphides were easily detected on the trees, but the parasite population did not appear to be very great. This work is being carried out in collaboration with the Plant Pathological Laboratory, Harpenden, Herts.

Apple fruit sawfly investigations.

Some new and interesting observations on the life-cycle of this insect have been made during the season of 1932. It has been ascertained that a considerable proportion of the larvæ make what might well be termed a " temporary nocturnal migration." This form of migration takes place during the period from the hatching of the egg until the larvæ are ready to go into the soil. The larvæ come out of the developing fruitlets after night-fall, and they usually go back again before daylight. It has been noted that once a Sawfly larva migrates from one fruitlet, it may not go back into the same fruit again, but may attack a healthy fruitlet in the same truss. Thus, all the fruitlets in one truss may be ruined by one larva.

A preliminary account of these observations has been published (30).

Systematic study of gall mites.

A systematic study of the gall mites which infest plants is being continued, and a new species from South India has been described. A description of the mite, together with details of the gall formation produced by the species is in the press.

A new Tarsonemid mite.

A species of Tarsonemid mite hitherto unknown in this country was sent to East Malling for determination. The mite occurs on bulbs. The species has been determined as being *Tarsonemus approximatus var. narcissi Ewing*. A detailed account of the mite has been forwarded for publication.

The strawberry tarsonemid mite.

It has now become definitely established that the strawberry tarsonemid mite is commonly distributed in this country and that it attacks many commercial varieties (25).

It has also been shown that direct mite injury to the plant may result in the plant losing its vigour and cause general deterioration. In addition it has been noted that once a badly mite-infested plant has been cleaned of mites the plant may or may not regain its vigour. When the plant does not recover it is suggested that some other factor may be present, but that it is masked by the severity of the mite infestation.

Control measures.—It has been found that lime-sulphur applied at a strength of 3 per cent. will kill the mites, but this treatment is by no means efficient since it does not affect the eggs. Other acaricides are being tested, and it has been found that white oil preparations are not very efficient against the mite.

In a preliminary experiment it has been found that the treatment of strawberry plants by sterilizing them in hot water at a given temperature, for a known period, has given very satisfactory

indications. The plants are not damaged by the treatment, but the mites and their eggs are destroyed.

Strawberry "yellow-edge" disease.

Investigations are being continued in collaboration with the Mycological Section to determine whether the mite (*T. fragariae Zimm.*) is associated with the transmission of the virus causing the disease described as " strawberry yellow-edge." Direct inoculation experiments have been made with mites fed on diseased and healthy plants, but at present no positive results have been obtained, because the plants became so badly mite-infested during the autumn that any other symptoms which may have been present would be masked by mite attack. The plants have now been freed of mites and they will be kept under observation next year.

The blackberry mites.

It has been possible to make a few observations on the gall mite which causes " redberry disease," but no control measures have been attempted this year.

The apple blossom weevil.

Further observations on the life cycle of the Apple Blossom Weevil have been noted, and these are fully described in an account published recently (31).

Further trials have been carried out with various types of corrugated bands which had been chemically treated in an attempt to render them less liable to attack by birds and mice. The results are encouraging, but the investigation must be continued, since a number of the treated bands have been subject to attack by birds, though not to the same extent as the untreated ones.

A preliminary trial has been started to determine whether apple blossom weevils can be induced to shelter in chemically treated bands which will in time destroy the weevils. Tests made with bands treated with beta-naphthol gave negative results.

The apple fruit tortrix.

Preliminary observations on the habits and life-cycle of this tortrix (*Batodes Sp.* ?) have been made during 1932. This pest is now very serious in some districts in Kent, 50 per cent. of the crop in some plantations being affected.

Raspberry and loganberry beetle.

Observations continued to be made on the habits of this pest with special reference to the larvæ, and further field trials on raspberries and loganberries were carried out with derris sprays and dusts of known rotenone content.

Whilst amply confirming the adequacy of the East Malling double-spraying method of control (which entails spraying with

derris in the middle and towards the end of June (32, 33)), these trials showed also that the larvæ can be attacked at a rather later stage than was originally thought desirable. In fact, as good results were obtained with one spraying (omitting the mid-June application) as with two. Confirmation of this is forthcoming from the results of delayed applications of nicotine to raspberries and the observed fact that larvæ do not do any damage of consequence till late June or early July.

A dust of known rotenone content again gave good results on raspberries when used against the larvæ, but was rather less efficient than wet sprays for this purpose.

Preliminary experiments showed that the pest could be controlled in its larval stage on cultivated blackberries by means of derris, though details as regards number and time of applications remain to be worked out.

The 1932 spraying trials, to the success of which the chemical assistance and advice given by Dr. Tattersfield, of the Rothamsted Department of Insecticides, materially contributed, form a basis for further work towards the standardisation of derris sprays and dusts. The full details of these trials will shortly be published, and the previous year's results have already appeared (32).

A leaflet dealing with the control of this pest was prepared for issue to growers and enquirers, and is being revised from time to time.

Other rubus pests.

Observations were made on *Eucosma* (*Aspis*) *uddmanniana* (Bramble shoot moth) on loganberries and blackberries, and on *Rhynchites ænovirens* on loganberries, blackberries and raspberries. The latter is apparently an hitherto unrecorded pest of *Rubus* with somewhat similar habits to the apple twig cutting *Rhynchites*, but is not at present of great importance.

Insect transmission of raspberry mosaic.

The infection experiment with potted plants of Lloyd George and Baumforth B has been continued, but without any positive result to date.

Capsidæ.

In collaboration with Wye College a winter spraying trial against the apple capsid (*Plesiocoris rugicollis*) planned on statistical lines, was carried out on a commercial farm. The sprays used were a light lubricating oil, a strained anthracene (tar) oil—both of known characteristics—and a mixture of these. Very good control of capsid was obtained with sprays containing 6 per cent. of the mineral oil, with or without the addition of 4 per cent. of the tar oil. The results are being prepared for publication.

Derris.

Some preliminary biological tests have been made with a view to developing a technique for use in extensive biological tests to be carried out jointly with Dr. Tattersfield, of Rothamsted.

HOPS.

Cultural trials.—The investigation of the effect of the distance between the hills and the number of bines trained up each string on the yield and on the size of the cones has been continued. Although the weather conditions in 1932 were very different from those of 1931, the relative cropping of the plots remained unaltered, the yields again being markedly increased by closer planting. The number of bines trained up each string still appears to affect the yield much less markedly than the distance apart of the hills. On inspection of the plots at picking time the cones on all plots appeared very well developed, but the grading of random samples of cones showed that the significant differences in size between the treatments noted last season still remained.

Samples of the dried hops of the 1931 growth were taken from plots having the two extreme treatments (3ft. apart, 3 bines per string, and 9 ft. apart, 1 bine per string) and analysed for preservative value by Mr. Burgess, of the South-Eastern Agricultural College. The cones from the hills 9 ft. apart proved slightly the richer. An analysis of this year's hops is being made in order to see if the difference in preservative value is maintained.

The seedling OV 7 (Late Bavarian x English Male) has been propagated in sufficient quantity to allow of half an acre of this variety being planted during the winter. This area will be used for further cultural trials and to provide material for brewing tests and also sets for distribution to growers.

The two half-acre plots of seedling OP 21 and the commercial variety Fuggles planted in October, 1931, are being allowed to become thoroughly established before the proposed trials of severity in cutting and pulling are commenced.

Manurial experiments.—A report on the pot culture experiments has been published, giving the results of five years' observations (34). Descriptions of the foliage characters associated with omission of certain elements from the nutrient solution are given and the effect of the treatments on growth, weight of bine and rootstock and cone formation are also discussed.

New seedlings.—A further twenty of Professor Salmon's new seedlings have been planted out for a preliminary trial, and a corresponding number of varieties which have proved to be unworthy of further testing have been grubbed. The crops from over 180 seedlings were dried separately and the number of bushels of green hops and the weight of dried hops recorded. Bottle samples of the dried hops for resin analysis were taken from over 100 varieties.

The cold, wet summer of 1931 had a depressing effect on the yield and the preservative value of the hops, but many of the seedlings were richer in preservative value than comparable commercial varieties. Among the early hops in 1931, X 35 proved once again to be richer than the Bramling. In the mid-season hops, seven varieties were higher in preservative value than the richest commercial variety (Mathon) and one of these had not been previously tested.

Of the late varieties, eleven seedlings proved richer than the richest commercial hop (Canterbury Golding). One of these, OP 21, is one that can be unhesitatingly recommended for the English market, and it is being propagated in quantity for distribution in the near future. The seedling C 9a, which in the three previous seasons proved richer than the richest American hops, came very slightly below it in 1931.

The evidence which has been gathered during the past few years indicates that several of the " Manitoba Seedlings," of which C 9a is an example, and also certain of the " New Mexican Seedlings " may have a commercial future in this country as hops suitable for " Stouts," with a preservative value equal to good American hops. This work is being carried out in collaboration with Professor Salmon, who has published a report (35), and with Mr. Burgess, of the South-Eastern Agricultural College.

Incidence of downy mildew.—The attack of the " spike " form of the disease was extremely severe, a special feature being the very large number of lateral " spikes " in the axils of the leaves during the second half of June and the early part of July.

Two applications of Bordeaux mixture were given (July 27th and August 10th) which gave satisfactory control of the disease on the cones with few exceptions. From observations made this season, it appears that the dates for applying the Bordeaux mixture to secure full control vary considerably with the variety and that with an experimental garden of several hundred varieties of all seasons and varying degrees of susceptibility, it is difficult to obtain a perfect control of the disease on every variety.

Titles of papers issued during the year.

1. *Annual Report.* I General, 1931. May, 1932.
2. *Annual Report.* II Supplement., 1931. May, 1932.

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6. ————: The pruning and renovation of apple trees. *E. Malling Res. Sta. Ann. Rep.* 1931, 61–66, May, 1932.

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9. Harris, R. V.: Disease and better fruit. *Fruit Grower*, **72**, 840–842, 1931.
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19. ————: Bacterial canker as a cause of dieback in plum trees. *J. Min. Agric.*, **39**, 208–217, 1932.
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22. ————: Apples should be picked with their stalks. *Ibid.*, **92**, 200, 1932.
23. Moore, M. H.: The control of apple scab. *Reading U., Bull.* **41**, 58–69, 1931.

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14. HORTICULTURAL RESEARCH STATION, CAMBRIDGE UNIVERSITY.

Plant Breeding.

Until April, 1932, the Director had no full time assistant. In these circumstances detailed observation and recording of results with a large number of crops was, of course, impossible. The method adopted was, therefore, to keep stocks in being by means of small mass selections and to continue the work of improvement by working on broad lines. A certain amount of crossing and selfing was, of course, carried out as usual. In this work the Director was helped by Mr. Clay (now the Geneticist to the Station). No trials of commercial stocks were possible this year.

Canning beans.—Research on this vegetable was begun at the instance of the Ministry of Agriculture. A definite type of bean is required by the canning industry in the form of ripe seeds. Seed has hitherto been obtained from Hungary or Japan, the varieties used for canning being apparently unable to ripen their seeds in this country. The problem is, therefore, to evolve a bean suitable for canning which will ripen a full crop in this country and thus afford a fresh side-line for market gardeners and farmers.

In 1931 a trial was held of varieties used for canning purposes in England and America. Each stock proved to be a collection of varieties differing in time of ripening, size and shape of seed, vigour, height of plant, and in other characters. A few plants were found which, in spite of a wet season and a late sowing, had ripened a crop of seed. The seed of these plants was harvested separately and samples were submitted to the experts of Messrs. Crosse and Blackwell. Two samples were approved by these experts as being of the required type, while others showed a close approximation to it.

This year the seed of the approved plants was sown and a trial was also made of a French variety which contains plants suitable for breeding purposes.

The crop at the time of writing awaits examination. Field observations show that many early maturing plants of canning types are present in the cultures.

As this vegetable is attacked by virus disease, it will also be necessary to evolve a variety resistant to this disease.

Broccoli (Roscoff type).—Work on this vegetable was also undertaken at the request of the Ministry. Reasonably true breeding stocks of early, mid-season and late broccoli are required; also, since the Roscoff type of broccoli is not hardy in all parts of this country, hardier types are needed so that its cultivation may be extended beyond the South and South-West of England.

A selection of plants was made from stocks which had been grown under the supervision of Mr. Oldham (of the Ministry of Agriculture) for several years and breeding work was begun at Cambridge. A trial of different stocks was also held at the Station.

Two acres of plants raised from seed produced at the Station were grown in Hayling Island on land lent by a grower. These cultures were extremely successful and after a rigorous selection had been practised a large number of plants was seeded *in situ* to afford material for further trials and possibly for distribution. In addition, about 70 early maturing plants were removed to Cambridge and 25 crosses made under glass.

The seed is not all threshed out yet, but the total yield from these selected plants will be in the region of 56 lbs.

There is material available for rapidly improving this important crop, given adequate facilities.

Brussels sprouts.—Work on this vegetable has advanced to a stage where it would be possible to distribute seed of improved strains provided that facilities for testing these strains and raising sufficient seed of them for distribution were available.

About 4 acres of our stocks are being grown on land lent by growers. It is hoped that it will be possible to seed a selection of plants from these stocks. This possibility, of course, depends on whether time for examination and money for travelling can be spared.

Cauliflower.—Attention has been chiefly directed to breeding for early maturity, semi-dwarf habit, and large dome-shaped curds (as distinct from the flat curd of All the Year Round or Driancourt, usually favoured by market growers).

Conditions were unfavourable both at Cambridge, Kirton and Haying Island at planting time this year, and since the plants at Cambridge were obviously not going to show their full possibilities, they were ploughed in at an early stage. The Hayling Island cultures were seriously checked by the hot, dry weather and no observations were taken on them. The results of the Kirton trial where attention was chiefly given to the pickling possibilities of

the stocks) are not yet available. At least 5 acres of suitable ground would be needed to try out the material bred at the station.

Cabbage.—Only a few definite suggestions for the improvement of cabbages have been received from growers. Hence, in the case of white cabbages, the work is being confined to the production of a small early solid spring cabbage of Ellam's Early type and a cabbage of Christmas Drumhead type.

At the suggestion of the Ministry, work has been begun on pickling cabbages, and a preliminary trial of commercial red cabbage is being carried out on the Middlesex County Council's Demonstration Ground at Denham.

Celery.—It has not been found possible to continue the work on celery this year. The crop of seed from 55 selected plants therefore remains for the present in its packets.

Lettuce.—Preliminary work in the form of trials of varieties was carried out during three successive years, seed was saved from selected plants, and much valuable information gained for future breeding work. Further work will, however, have to be deferred until more space is available.

Gherkins.—Work on gherkins was begun at the request of the Ministry. The Station was asked to explore the possibilities of growing gherkins of the type required by the pickling firms in this country.

A trial of French varieties was held this year. These proved to contain a large number of types ; samples were therefore submitted to a pickling firm, who selected specimens conforming to their requirements.

Seed has been saved from a number of selected plants.

No special care was taken with this crop. The seed was sown in the open ground and germinated well. In order to select plants having the best constitution, the plants were not even given the treatment considered necessary for ridge cucumbers. Nevertheless a good crop was harvested.

An unexpected complication was the prevalence of the virus disease causing mosaic in the various cultures. Plants resistant to this disease were, however, present, and seed from them will form the basis of future work.

Onions.—Work on these has been mainly confined to maintaining and improving strains already raised which are likely to be either commercially or genetically useful. 196 cultures of our own material were grown on the Station this year, and await examination. 220 selected bulbs were selfed and 56 small mass selections were grown for seed.

Last season a well-known firm of seedsmen offered to purchase six of our stocks, but for obvious reasons this offer could not be entertained. It is quoted, however, as showing that a certain amount of progress has been made in onion breeding.

Parsnips.—Work on this vegetable was begun in 1925 at the request of a member of the Commitee of the Station, who explained that the chief need in his area was for a parsnip of intermediate type (the shape of a James' Intermediate carrot) as distinct from the long types so popular at horticultural shows, but useless for commercial work.

The material from which the Cambridge selections originated came from Bedfordshire. From time to time small trials have been made of commercial stocks, but nothing has been encountered from which fresh material for breeding could be safely selected.

Only small cultures of this vegetable can be grown each year, and as the work of selfing and crossing parsnips is extremely time-consuming and tedious, the method used has been chiefly that of saving seed from single plants of small mass selections.

A very interesting and important point is the varying incidence of parsnip canker on these different stocks. Last year, for instance, practically every root of one culture was attacked, whereas the incidence on a culture growing side by side with it was negligible. Breeding for resistance to canker will, therefore, be an addition to the programme of work on parsnips.

Parsnip canker, of course, is a very serious trouble in Bedfordshire and in other areas.

Peas.—Sowing this year was delayed until June 11th, in order that the very unfavourable conditions usually prevailing at the Station during late summer and autumn might afford a severe test of constitution and ability to resist fungoid and insect pests.

Much of the work now in progress is concerned with selection in the hybrid progeny derived from crosses made in 1927. Desired combinations of parental characters have been segregated and a number of distinct stocks await trial against commercial varieties.

As an indication of advances already made, some results of testing a stock of "Little Marvel" (obtained from a well-known firm) against varieties of similar type raised at the Station, may be quoted.

Ignoring the five classes of "rogues" present in the trade stock (these comprised 15 per cent. of the plants), the proportion of double flowered racemes it produced was 12 per cent.; the figures for four of the Research Station stocks were 50 per cent., 45 per cent., 33 per cent., and 69 per cent.

A variety has been raised in which the size of the pod and seed has been increased 20 per cent. without sacrificing any of the desirable qualities of the original small podded parent (a "Little Marvel" type) of the stock. Other stocks are noteworthy for features such as unusually dark and glaucous foliage; high degree of resistance (practically amounting to immunity) to mosaic; decreased susceptibility to attacks of pea moth and thrips; and and high quality peas of large size (up to 0.5 grm. each in the dried state), combined with dwarf early habit.

Work on canning peas is being continued. For the second time the reports on canning trials of two varieties raised here have been favourable both as to appearance and quality of the canned product.

Seed of a number of crosses and of various F_1 cultures remains unsown. Very many single plant selections, together with seed of stocks considered to be worth trial, similarly await the time when space will be available for them.

Strawberries.—Of the 2,000 seedlings raised from 1930 crosses about 65 per cent. fruited this year. 228 of these were selected for propagation on a small scale. The trial of most of these seedlings, for reasons which have already been emphasised, will have to take place away from the Station. This will, of course, hamper observations of their behaviour and the fact that they will be on soils differing from that of the Research Station will render comparison with plants remaining on the Station very difficult.

Further testing of a large number of seedlings is necessary for the following reasons:—The fruit characteristics of a seedling cannot be judged accurately from a single plant; moreover, the first fruiting of a seedling may give a poor, or even a misleading, idea of its normal period of ripening, fruit size, and cropping capacity. Degree of vigour and resistance to diseases similarly cannot be judged from a single plant in its first season, and there is also the possibility that the season may have been peculiarly favourable, or adverse, to the plant.

A suspicion that excessive foliage and poor fruit production in seedling plants may offer no accurate indication of future behaviour has been confirmed. Two small clones of three plants each characterised in 1930 (as maidens) and in 1931 by few and weak strigs behaved similarly this year. Maidens taken from these plants have, however, fruited freely.

In short, it may be said that a too rigorous selection is most inadvisable during the early stages of the trial of a seedling.

Resistance to disease, and particularly to the disease generally attributed to a virus, is considered to be a factor of primary importance in breeding strawberries. Attention is also being directed to "Wilt" disease, mildew, and leaf-spot.

Suitability of the fruit for preserving purposes, both for canning and for jam-making, is, of course, being kept in view in the breeding work. Canning and jamming tests of these seedling varieties were conducted this year by Mr. Morris, of the Cambridge Low Temperature Research Station. Next year it will be possible to make fuller use of his co-operation in carrying out preserving tests.

With the fruiting of many more seedlings this year it is becoming possible not only to formulate broad general ideas as to the genetic behaviour of strawberries but, in addition, to determine which varieties tend to be the more valuable as parents.

As with other plants, such " progeny tests " seem to indicate that individuals good in themselves are not necessarily the best parents. Indications derived from such tests are therefore valuable, especially where the elusive and complex quality termed " good constitution " is concerned.

The expectation that selfing might lead to an almost uniform production of weakly plants has now been confirmed.

Seed derived from 51 different cross pollinations has been obtained this year. There is, of course, no space on the Station for the plants which will be raised from this seed.

Chemistry.

Work on the physico-chemical properties of sprays has been continued. A method of evaluation of sulphur suspensions has been evolved. New tests for determination of emulsion type in a fluid have been found, as the old standard tests were sometimes misleading. Proteins and allied substances and lipoids have been proved to be useless emulsifiers in the preparation of spraying emulsions of certain oils, because they may give the wrong type of emulsion.

Oil-containing soaps which give emulsions by mere soaking in water have been prepared, but the quantity of oil embodied is not sufficient to warrant general use. A new miscible oil for soft waters, of possible use in summer spraying, has been made, the aid to dissolution being less phytocidal than the phenols usually added to such washes for this purpose.

Investigations on seed treatment with mercury compounds and formalin, on attractants for carrot fly, and on the mechanics of spraying, have been commenced. A study of weed killers for use against wild onion and weeds generally on fallow land has been made, spreaders being incorporated with the washes.

The compressibility of clays under small pressures and the true specific gravity of clays have been studied, the influence of the exchangeable base present being taken into account.

Pests and Diseases.

Mycology.—Most of the mycological work carried out in the year 1931-32 has been concerned with club-root of crucifers, white rot of onions and a wilt disease of strawberries apparently due to a species of *Verticillium*.

Attempts have been made to develop a technique for testing in the seedling stage the resistance to club-root of different varieties of *Brassicæ*, mainly brussels sprouts.

Promising results have been obtained by the use of the following methods :—

(i) Plants are grown from seed in unsterilised naturally infected soil from Bedfordshire or in a mixture of equal parts of this soil and of potting soil.

(ii) Plants are grown in steam sterilised soil ; the seedlings and the surrounding soil are sprayed with a spore-suspension of *Plasmodiophora brassicæ*. Both soil from Bedfordshire (pH 6.3 approximately) and potting soil (pH 7.2 approximately) were used. Spore-suspensions were made both from rather old clubs and from fresh young ones and in one experiment two different concentrations of the spore-suspension were employed.

The results so far obtained show that reasonably high percentage infections can be obtained even in alkaline soil if the spore-suspension is made from fresh young clubs, and if it is sufficiently concentrated.

In 1931 ten varieties of brussels sprouts were grown in heavily-infected land in Bedfordshire. In November, 1931, every plant (over 1,000 in all) was found to be clubbed. But whereas in some varieties only 6-7 per cent. of the plants produced a saleable crop, in others this percentage was over 30. The same plot of infected land was planted in 1932 with other varieties for a similar test.

It is hoped in the future to carry out work on the chemical treatment of the disease in the field. With this in view experiments have been started to test the effect on plant growth (in particular, on root development) of some of the chemicals likely to be employed, *e.g.*, mercuric chloride, sodium and potassium carbonates, etc. These experiments are being carried out in collaboration with Dr. R. M. Woodman.

A preliminary experiment to investigate the relative numbers of germinating spores of *P. brassicæ* present in soil at various intervals after its inoculation with fresh young clubs is also in progress.

Work on white rot of onions has so far been confined to the testing for resistance of a number of varieties produced at the Station, as well as of some commercial varieties. The infection method used has proved satisfactory. White Welsh (*Allium fistulosum*), stated to be highly resistant to white rot, has been included in the experiment, but showed 54 per cent. infection ; in the same experiment the susceptible variety White Lisbon was infected to the extent of 71 per cent.

A wilt disease of strawberries causing severe losses in the trial beds at the Station has been investigated. Subsequently Mr. J. E. Spickernell, of the Ministry's Inspectorate, drew attention to a serious case of the disease in the King's Lynn district, where, thanks to the co-operation of the grower concerned, field work on the disease is being carried out. Maiden plants are most severely affected, but the disease is common on second year plants and may occur on still older ones. The symptoms may appear at any time from the middle of June to the end of the growing season, but the most serious outbreaks seem to occur in July. The wilt is often sudden, so that the plant dies in a few days ; in other cases it may survive, in a weakened state, until the following season. Oberschlesien seems particularly

susceptible ; other commercial varieties such as Paxton, Royal Sovereign, Little Scarlet, Black Prince, British Queen, Dr. Hogg, etc., are also affected.

The cause of the disease appears to be a *Verticillium*, two different strains of which have been isolated, one (provisionally called V (B)) from affected plants at Cambridge, the other V (a) from plants at King's Lynn. The strains differ in their appearance in culture owing largely to the formation by only one of them V (*b*) of microsclerotia ; they differ also in spore size and in temperature relations. V (*a*) closely resembles *V. alboatrum* from potato, while in some respects V (*b*) resembles *V. dahliæ* from raspberries. Further work on the relation of V (*a*) and V (*b*) to one another and to *V. albo-atrum* and *V. dahliæ* will be carried out.

Large numbers of inoculations of comparatively large plants, were carried out without significant results being obtained. Lately however, by inoculating the stolons leading to young runners still attached to the parent plants, successful inoculations have been made with V (*a*), V (*b*) and *V. albo-atrum.* The controls remained healthy. *V. dahliæ* was not included in this particular experiment.

Both at Cambridge and in the King's Lynn district the disease appears only to occur on strawberry beds which were laid down soon after potatoes. There is no satisfactory evidence that any of the potato crops concerned were affected by *Verticillium* wilt. Inoculation experiments with pot plants have shown, however, that both V (*a*) and V (*b*) can cause a wilt of potatoes, although they appear somewhat less toxic to this host than does the strain of *V. albo-atrum* originally isolated from potatoes.

Attempts at controlling the disease by a partial soil sterilisation and by various manurial treatments are being made in the field at King's Lynn.

During the year 1932–33 it is proposed to continue the work on these three diseases ; in addition work on the *Marssonina* ring-spot disease of lettuce is now being started. If possible, some work on *Botrytis* neck-rot of onions will also be carried out.

Entomology.

Carrots : Carrot fly (*Psila rosae*). *First Generation.*—On April 26th cages were set up in a fen farm field on which carrots had been grown last year. Carrot flies were taken for the first time this year on May 14th. No flies were taken after July 6th.

Second generation.—A large cage was placed over young growing carrots on the farm mentioned above. The first flies were taken on August 24th. The experiment (carried out in collaboration with Mr. F. R. Petherbridge) is not yet concluded.

Attractants for P. rosae.—Various substances were tried with a view to attracting the carrot fly to poisoned baits. The results have, so far, been negative. This experiment was carried out in collaboration with Dr. R. M. Woodman.

Deterrents for P. rosae.—An experiment to test the value of crude naphthalene as a deterrent for carrot fly has been carried out in collaboration with Mr. F. R. Petherbridge. Results will not be available until the carrots on the various experimental plots have been lifted.

Peas.—Fields have been visited periodically throughout the season in Cambridgeshire, Huntingdonshire, and Bedfordshire. Some thrips and a few midges were observed, but no damage was encountered. Unfortunately the season proved unsuitable for carrying out observations on the pests of this crop.

Parsley.—Damage to this crop was reported from a farm in Bedfordshire last season. Larvæ of *Lonchaea flavidipennis* were found in the decaying stems, but not in sufficient numbers to account for the initial damage.

Parsley and carrots left for seed were reported this season as being similarly attacked. No insect pest was found. A fungus (identified by Mr. Brenchley as a *Fusarium* sp.) was present.

Onions.—848 pupæ of the onion fly (*H. antiqua*) were received from the Plant Breeding Department of the Research Station. No parasites were bred from these pupæ.

Cauliflower.—Larvæ of *Phytomiza rufipes* were found attacking stalks of the inflorescence of a cauliflower taken from the Research Station on June 15th, 1931.

Titles of papers issued during the year.

1. Woodman, R. M.: The compatibility of fungicides and insecticides. *N.F.U. Yr. Bk.*, 401, 1931.
2. ————: An examination of some commercial substances used in the spraying of plants. *J. Soc. Chem. Ind.*, **50**, 391 T, 1931.
3. ————: The evaluation of sulphur suspensions used in spraying. *Ibid.*, **51**, 103 T, 1932.
4. ————: Experiments on lecithin as an emulsifier, with some observations on the drop method of determining emulsion type. *Ibid.*, **51**, 95 T, 1932.
5. Woodman, R. M. and Jones, W. A.: The eradication of weeds by chemicals. *Chem. News*, **144**, 21, 1932.
6. Wright, C.W.B., and Woodman, R.M.: Problems confronting the sprayer—I. The volume of liquid needed to spray trees of varying sizes and shapes. *Ibid.*, **144**, 116, 1932.
7. ———— ————: Problems confronting the sprayer—II. The volume of spray passing through nozzles of varying diameters at varying pressures. *Ibid.*, **144**, 1932.
8. Woodman, R.M.: Determination of emulsion type. *Ibid.*, **144**, 225, 1932.
9. ————: Studies in dual emulsions. *Chem. Age*, **25**, 146, 1931.
10. Taylor, E. M., Woodman, R. M., and Hanley, F.: A note on the reclamation of a greenhouse soil. *Chem. News*, **143**, 309, 1931.
11. Woodman, R.M. and Chapman, G. W.: The behaviour of clay gels under small pressures and the influence of the exchangeable base present. *J. Soc. Chem. Ind.*, **51**, 175 T, 1932.
12. Woodman, R.M.: Note on the true specific gravity of colloid-containing materials such as the bentonites. *Ibid.*, **51**, 327 T, 1932.

15. EXPERIMENTAL AND RESEARCH STATION, CHESHUNT.

Manurial and Crop Management Trials.

Tomatoes.

Manurial and crop management trials with tomatoes have been continued. The experiments relating to the relative effects of different nitrogenous fertilisers were continued after steaming the soil during the preceding autumn. As growth was remarkably good, a further addition of nitrogen was not attempted and the results obtained are indicative of the effect produced by steaming plots previously treated with different nitrogenous fertilisers. They suggest that steaming so affects the soil that the previous differences due to the different compounds are annulled.

An experiment was commenced whereby the young plants were set out in trenches, which were later filled up with composts of different kinds. Wireworm injury resulted from the use of fresh turf, and the greatest improvement was observed where the trenches were filled with a compost consisting half of peat and half of soil. The experiment will be repeated.

Experiments in connection with soil improvement by the addition of such materials as peat, straw, spent hops, and chrysanthemum roots were continued.

While the crop was increased by these treatments, the improvement was not so great as in the previous season with the exception of spent hops which raised the crop some 25 per cent.

The value of such treatments has been proved on certain commercial nurseries especially those on heavy soils, and the work will be continued.

Some evidence was also obtained to suggest that the reduction in yield which accompanies the continuous cultivation of the tomato in the same soil in successive years is due to some factor which the tomato leaves behind in the soil, rather than to the removal of some important nutrient.

The liming experiments which have been in progress for five years indicated again that the value of lime to tomato soils has been over estimated, except where its addition is necessary to improve the physical condition.

The variety trials included a number of new crosses, but with the exception of those specially resistant to leaf mould none was outstanding. The resistant types shewed considerable improvement in quality of the crop over previous generations.

The oil fuel experiment was continued, and once again excellent temperature control was obtained. Owing to the number of hot water pipes in the houses being insufficient it is not possible to provide particulars of running costs. Additional pipes have been installed and it is hoped to obtain accurate data next season.

During the past year methods have been evolved which enable the physiology of the seedling tomato plant to be studied under normal cultural conditions. This involved the elaboration of a number of highly specialised methods.

Work is now in progress with a view to determining the light, temperature and water relations of photosynthesis, respiration, translocation and leaf expansion of the seedling tomato plant. A number of interesting indications have already been obtained.

While it is clear that assimilation is dependent upon both light and temperature at the time of assimilation, it has been found that several other factors occur, which may modify these relations. There is a considerable amount of evidence to show that assimilation is profoundly influenced by the night.

The investigations of the temperature relations of the tomato crop have amply confirmed previous experiments which have indicated that the optimum air temperature at night is between 63° F., and 65° F. The current experiments shewed quite clearly the injurious effect of low night temperatures on the setting of the fruit on the two lowest trusses.

The work on the nitrate-nitrogen content of a tomato soil and of the drainage from the same soil has been continued. The fluctuations in the nitrate values in the soil were similar to those already recorded. With the soil fallow and unmanured the amount of nitrate—nitrogen in the drainage was considerably higher than that found when the soil was manured and cropped. As was the case last year only a portion of the nitrate which disappeared from the soil after watering could be accounted for by nitrates in the drainage. The nitrogen lost in drainage in the form of ammonia was very small and amounted to less than 1 per cent. of the nitrogen found in the form of nitrate. The factor which is responsible for the disappearance of nitrate appears to operate in soil which has been partially sterilised by steaming. It has been shown that merely wetting the soil so as to preclude the possibility of leaching may cause a disappearance of nitrate, but the data available suggest that, under certain conditions at all events, the disappearance of nitrate does not mean an actual loss of nitrogen other than that caused by leaching, It appears probable that the nitrates are decomposed and the resulting products are retained in the soil and these may later give rise to nitrates again.

Cucumbers.

The cucumber experiments were designed to determine the effect of raising the bed temperature some 15° F. at night. This was done by laying on top of the base and immediately beneath the beds a series of wires which were heated electrically.

The results indicated that the weight of the cucumber crop is to some extent dependent upon the temperature of the compost in which the plants are growing.

Where the base was sterilised by steam and baked soil was used for making up the bed the crop increase was of the order of 10 per cent. only, but in the case of unsterilised soil the increase amounted to 33 per cent.

The weight of crop produced, however, was slightly higher in the case of the heated and sterilised plots than it was when the soil was heated but not sterilised.

These results raise several interesting points for they appear to suggest that the injurious influences present in cucumber soil can be counteracted either by steam sterilisation before making up the beds or by maintaining a bed temperature about 15° F. above the normal.

Lettuce.

As in previous years, a catch crop of lettuce was grown during the winter in the tomato houses. The experiment was conducted on a large scale, and proved that this crop can be grown successfully by the methods recommended.

Work on the improvement of existing varieties has been commenced with the object of raising strains which will heart well during the winter period. Promising results have been obtained.

Pests and Diseases.

The red spider investigations have been continued. A sulphonated oil product was tested as a means of controlling this pest on tomatoes, and while complete control of the mite was obtained at a dilution of 1 part in 250 parts of water its tendency to cause *Oedema* gave it no advantage over the oil emulsions already in use.

An unsuccessful attempt was also made to render the tomato plant more resistant to attack by feeding with certain compounds. Treatment with salts of sodium, barium, magnesium and manganese applied to the soil has shown that an increase rather than a decrease in the feeding of the mite upon the foliage takes place after application.

The breeding and distribution of the white fly parasite, *Encarsia formosa*, Gahan, has been continued as in previous years. The demand for this material continues.

Work on the larvæ of the cucumber root flies has shown that one of the most important of these, *Sciara auripila* Winn. is brought into cucumber houses in the turf used for making up the beds. Attacks upon pot plants, in the propagation house, appear to result from these plants being kept under the same roof as the beds, which are planted at a later date.

The larvae caused serious damage on several nurseries early in the year.

Previously a soil drench of mercuric chloride at a concentration of 1 in 1,000 applied to mature plants had given promising results, but early this year it was found to be unsuitable for young plants, as it caused severe hardening. Many new substances were tested

and it was found that a compound consisting of nicotine in a sulphonated oil gave complete control of the maggot at a strength of 1 in 500 and could be used at all stages of plant growth.

Investigations in relation to woodlice are in progress for the purpose of discovering a substitute for Paris Green in baits used for destroying these animals. Dried blood is being employed as a medium for distributing substances poisonous to woodlice.

Thrips constitute an important pest of many glasshouse plants, and it has been shown, by breeding specimens under isolated conditions that the glasshouse rose thrips (*Thrips fuscipennis Hal.*) is a species quite distinct from the outdoor rose thrips (*Thrips major Uzel*). Structural characters have now been found by which the females of the two insects can be separated with ease and certainty.

A dust containing naphthalene, lime and nicotine has proved most effective in destroying the onion thrips (*Thrips tabaci Lind.*) a pest of cucumber, arum, cyclamen and carnation plants. Experiments with this dust upon the rose thrips are at present incomplete. It was proved effective as a control for the hot house thrips (*Heliothrips femoralis Rent*).

The mixture of Salicylanilide and Agral I has been used extensively on nurseries, for the purpose of controlling leaf mould (*Cladosporium fulvum*). When applied as soon as the disease made its appearance good results have been obtained.

When used as a means of controlling powdery mildew of the cucumber, a slight scorching of the foliage was observed on young plants, but this was overcome by replacing Agral I by Agral N. Agral N is more highly concentrated than Agral I, and only half the quantity should be used.

A spray mixture consisting of $\frac{1}{8}$ oz. Shirlan Paste (Salicylanilide) and $\frac{1}{8}$ oz. Agral N in 1 gallon of water has been used with success as a means of controlling this disease.

A great deal of attention has been given to a disease of the chrysanthemum which has been named " leafy gall." The disease is infectious, and affects the young growths which spring from the base of the flowering stems, and which should provide cuttings for the following season. An affected shoot branches repeatedly to form a dense mass of short, thickened shoots with small distorted leaves, and when the disease is severe it is difficult to obtain an adequate supply of cuttings. A bacterium has been isolated which produces swellings in the stems of chrysanthemum and tomato plants, but the precise symptoms of " leafy gall " have not yet been produced by inoculation.

In culture, the organism resembles closely the " crown gall " organism, *Bacterium tumefaciens*.

Preliminary experiments with a view to prevention and control have been carried out, and observations concerning the susceptibility of varieties and the history of gall formation have been made.

Virus diseases.

The investigation of virus diseases has been continued.

Further work on the effect of the virus of *aucuba* mosaic on the metabolism of the tomato plant has shown that there is a slight increase in the starch content of the infected plants shortly after inoculation followed by a marked decrease as compared with healthy plants. The decrease is most pronounced under conditions of high light intensity. The amounts of reducing and non-reducing sugars also show variations which are most marked in the decrease of sugars after 12 hours' darkness in plants suffering from *aucuba* mosaic as compared with an increase in the healthy plants. The variations in carbohydrate contents in periods of two hours throughout 24-hour periods are under investigation as is the nitrogen distribution. In general there appears to be an increase in the total nitrogen content of the plants infected with *aucuba* mosaic as compared with the controls.

Tomato plants affected by " spotted wilt " have been received at Cheshunt this season for the first time. " Spotted wilt " is an extremely serious disease of tomatoes in Australia, and as it now appears to be of fairly frequent occurrence in this country it is a potential danger to the tomato crop. Studies have been made of this disease on tomatoes and other plants.

Investigations into the mosaic, " stripe " and streak group of diseases have been continued. Ordinary or mild tomato mosaic in this country has been identified with true tobacco mosaic.

Titles of papers issued during the year.

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2. Read, W. H. : The toxicity of the vapours of volatile organic compounds to the " Red spider " mite (*Tetranychus telarius L.*). *Ibid.*, **19**, 3, 432–438, 1932.

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16. JOHN INNES HORTICULTURAL INSTITUTION, MERTON, LONDON.

Prof. J. B. S. Haldane has continued his work on the mathematical theory of selection (21) and other mathematical aspects of genetics (17, 22, 23). In a paper in the American Naturalist (18), he discusses the variation in time of action of genetic factors in the life history of plants and animals, which he concludes to be of considerable evolutionary importance. Dr. Darlington, in the same journal (11), marshals the by now imposing evidence for the genotypic control of the chromosomes, and discusses the problems involved in the conclusion that the chromosomes are subject as a whole to the variation in their parts.

Dr. Darlington and his collaborators have continued their work on chiasma formation (9, 10, 14, 15). Dr. Darlington has also published two books, one popular (13) and the other advanced (12), the latter embodying a good deal of his own work during the last five years. Dr. Sansome and Mr. Philp have published a volume on recent work in genetics (34).

Work on " synthetic " ring-formation in diploid plants is being carried on by Miss Pellew and Mrs. Richardson Sansome in *Pisum* (31), and by Miss Gairdner and Dr. Darlington in *Campanula persicifolia* (16). In *Pisum* several authors observed abnormal sterility in certain strains, and these strains on cytological examination proved to have each a ring of four chromosomes at meiosis. The same chromosomes are not involved in the ring in all aberrant strains, as two strains with rings of four on crossing gave a proportion of plants with rings of six. Similar results are found in the case of *Campanula persicifolia*. These facts are of theoretical importance in that *Pisum* and *Campanula* may be taken as showing the *Oenothera* rings in process of formation.

Mr. Mather has made a survey (29) of the cytology of the *Crocus* species which have been collected over a period of years by Dr. Collins. Mr. Dark has made quantitative observations (8, 14) on chiasma formation in triploid *Primula sinensis* and in the Orthopteran *Stenobothrus*. Mr. Moffett has investigated (30) abnormal pollen grain formation in *Kniphofia* and Mr. Lawrence has studied (26, 27) secondary association of chromosomes in *Cardamine* and *Verbascum* and discussed a large number of cases of its probable occurrence. Mr. Lawrence has now concluded his work on the origin and constitution of the garden *Dahlia*. A popular account has appeared in the Dahlia Year Book (28).

Mr. Crane has continued to collaborate with Dr. Zilva of the Lister Institute. Dr. Zilva's results (7) show that, although there is considerable variation within both classes, the triploid apples are definitely richer in vitamin C than the diploids. It is hoped to extend this investigation to other groups of plants where diploids and polyploids can be studied side by side, for example the tomato.

Miss Andersson-Kottő has published two papers on the genetics of ferns (2, 3) and in collaboration with Miss Gairdner is investigating species hybrids in *Dianthus*.

Mr. McKenny Hughes has concluded a long experiment on the induction of melanism in the moth *Selenia bilunaria* (24). No melanics were induced, the results being wholly negative and thus failing to confirm Harrison's findings (1926, 1928).

Work has been continued on pollen incompatibility and sterility among apples, plums and cherries, as material of known parentage is now available. New hybrid *Rubi* of various degrees of polyploidy have been raised, and the work on apple seedlings immune to woolly aphis which may be of value as stocks has been advanced, in conjunction with the East Malling Research Station, though on these

fruit questions no paper has been published within the year, with the exception of a note in " *Nature* " on chromatid segregation (6). The study of inheritance in the induced tetraploid tomatoes has been continued, and a report will be published shortly.

Titles of papers issued during the year.

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2. Andersson-Kottö, I.: The genetics of ferns. *Bibliographia Genet.*, **8**, 269–294, 1931.
3. ————: Observations on the inheritance of apospory and alternation of generations. *Svensk Bot. Tids.*, **26**, 99–106, 1932.
4. ————, and Gairdner, A. E.: Interspecific crosses in the genus *Dianthus*. *Genetica*, **13**, 77–112, 1931.
5. Crane, M. B.: Fertility in relation to yield in cultivated fruits. *Reading U., Bull*, **41**, 1932.
6. ————, and Darlington, C. D.: Chromatid segregation in tetraploid *Rubus*. *Nature*, **129**, 869, 1932.
7. ————, and Zilva, S. S.: The antiscorbutic vitamin of apples. *J. Pomol.*, **9**, 228–231, 1931.
8. Dark, S. O. S.: Chromosome association in the triploid *Primula sinensis*. *J. Genet.*, **25**, 91–95, 1931.
9. Darlington, C. D.: The analysis of chromosome pairing in *Triticum* hybrids. *Cytologia*, **3**, 21–25, 1931.
10. ————: Chiasma formation and chromosome pairing in *Fritillaria*. *Proc. 5th Int. Bot. Cong.*, 1930, 189–191, 1931.
11. ————: The control of the chromosomes by the genotype and its bearing on some evolutionary problems. *Amer. Nat.*, **66**, 5–24, 1932.
12. ————: *Recent advances in cytology*. London (Churchill), 1932.
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15. ————, and Janaki Ammal, E. K.: The origin and behaviour of chiasmata—I. Diploid and tetraploid *Tulipa*. *Bot. Gaz.*, **93**, 296–312, 1932.
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D.

ENTOMOLOGY
and
PLANT PATHOLOGY.

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17. PLANT PATHOLOGICAL LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

The activities of the laboratory are primarily concerned with questions arising out of the administration of the Destructive Insects and Pests Acts, with advisory and educational work, and with other matters relating to the diseases and pests of plants in which the Ministry may be concerned. Research is carried out only in so far as other duties permit, and is frequently part of a co-operative scheme, the laboratory acting as a connecting link between different research stations or advisory centres. Such work is reported upon by the stations or centres concerned and is therefore dealt with elsewhere in this volume.

Instances of the activities of the laboratory during the year under review are as follows : Special attention has been given to the extensive spread of the Colorado Beetle in France and the resulting menace to England, to the introduction of the Potato Moth in imported potatoes and methods of dealing with infested consignments, and to the possibilities of the arrival of dangerous pests and diseases from abroad on various other kinds of imported produce, notably fruit. Bulb diseases occuring both on imported and home-grown bulbs have been under investigation, and experiments designed to throw light on such troubles as " hard base " in tulips (on Couronne d'Or) and an alleged degeneration in daffodils (Golden Spur) are in progress. A large number of consignments of plants for export, including nearly a thousand samples of seeds, have been examined, and some attention has been given to seed troubles in peas, notably to marsh spot, of which the cause still remains obscure. The experiments in growing pyrethrum for insecticidal purposes, mentioned in the previous report, have been continued, and the results obtained from the plots grown on a commercial or semi-commercial scale indicate that, while good crops of high quality flowers can be produced in England, there is a great need for some form of mechanical harvester to reduce labour costs. Further introductions of the woolly aphis parasite, *Aphelinus mali*, have been made, and it would appear that the insect is established, at all events temporarily, in at least two localities. Considerable attention has been given to the question of standardising insecticides and fungicides, a problem of great importance and difficulty, both from the phytopathological and commercial points of view.

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18. POTATO VIRUS RESEARCH INSTITUTE, CAMBRIDGE UNIVERSITY.

Raising of virus-free stocks.

As in previous years, glasshouse stocks of virus-free potatoes have been maintained, and to them, amongst others, have been added McKelvie's latest introductions, Arran Pilot and Arran Scout. In

regard to these latter, the seed was received direct from McKelvie : 20 tubers of each were grown in the insect-proof house and at least half of each stock was found to be infected with the X virus and several of them with both X and Y. It is of interest to note that the clinical effect of these viruses on the plants till now has been very slight. Plants have, however, been selected which give no reaction and from which it is hoped to raise vigorous and healthy stocks.

In the field, isolated plots were grown of material in their first, second and third year from the glasshouse. All of these, although planted on ordinary heavy clay arable land, with no special preparation whatever, have done remarkably well. The first year material started in all cases healthy, and such slight seasonal infection as occurred was eradicated by rogueing. In certain varieties of the second and third year, particularly Abundance, Arran Banner and Kerr's Pink, the stocks were as good in appearance as those of the first year, and the crops correspondingly heavy. In all other varieties the appearance of these second and third year plots was decidedly superior to the potato crops of the district in which fresh Scotch seed was employed.

The research in the glasshouse has followed on the lines of last year. Further attempts at synthesis have been carried out and the phenomenon referred to in a paper published last year as auto-infection has engaged further attention. Its explanation will be one of the chief problems of the coming year.

The question of carrier formation is still being investigated : the principles underlying it have yet to be elucidated.

The examination of the streak diseases has been completed and a paper published by the Director and Mr. Bawden (2).

Mr. Bawden has completed the research on the histological necrotic lesions of the various streak diseases of the potato, as well as those found in leaf roll, the results of which have been published (1).

The raising of varieties genetically resistant to *Phytophthora infestans* infection has continued. Certain of these have shown almost absolute resistance in both tuber and leaf to the strain of the *Phytophthora* in use. Recently, however, a strain appeared in the field which seems to be able to attack at least some of those varieties which have been hitherto resistant. Miss O'Connor has raised a very large number of F_1 seedlings, and from these the F_2 generation will be grown and tested under glass in the coming season.

Entomology.

Further studies have been carried out upon the potato mosaic viruses isolated by Dr. Kenneth Smith and designated X and Y. These two are the commonest of the potato mosaic viruses in England and Y is probably the most destructive. Search has been continued for the insect vector of the X virus, and field experiments have been carried out to try and elucidate this point.

Preliminary investigations have been made into certain physical properties of the X and Y viruses : it has been found that these two viruses differ in a high degree in their adsorptive capacity and in other properties. It is hoped to correlate these differences in properties with differences in the relationship between these viruses and the insect vector.

Further work has been carried out upon the thrips-transmitted virus of tomatoes known as " spotted wilt " which was discovered by Dr. Kenneth Smith for the first time in England last year (4). The host range of the virus has been studied and various different ornamental plants frequently grown in glasshouses have been found susceptible to the virus. The importance of this is shown by the following example : A tomato grower complained that he had lost most of his crop for three consecutive years from an unknown disease in spite of soil sterilisation and change of seed. Investigation showed that the disease was " spotted wilt " and, further, that new infection was coming each year from a stock of double nasturtiums infected with the virus, which the grower had been propagating from cuttings for several years.

Mr. J. P. Doncaster has been occupied in the past year in assisting Dr. Kenneth Smith in his work on plant virus diseases. In this connection several series of experiments have been carried through to test the powers of various insects as vectors of virus diseases, and, in particular, to try to ascertain the incubation period of the virus of " spotted wilt " of tomato in *Thrips tabaci*. A special study has been made of the life history and bionomics of *Thrips tabaci* with a view to publication.

From June to September time has been spent in making observations in the field on the infestation of potato crops by aphids and other insects. This work has consisted in taking counts of the insects infesting a number of plants chosen at random in the field, and an attempt has been made to correlate the density of infestation with such factors as locality, soil conditions, variety of potato concerned, prevailing wind, and prevalence of virus disease. Observations have been made in the various localities in Cambridgeshire, Bedfordshire, and Hertfordshire.

Titles of papers issued during the year.

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2. Salaman, R. N., and Bawden, F. C. : An analysis of some necrotic virus diseases of the potato. *Ibid.*, **3**, 1932.
3. Salaman, R. N., and Hurst, C. C. : Inclusion bodies in virus diseases of the potato. *J. Roy. Micro. Soc.*, **52**, 237, 1932.
4. Smith, Kenneth M. : Studies on plant virus diseases : No. XI. Further experiments with a ringspot virus : its identification with spotted wilt of the tomato. *Ann. Appl. Biol.* **19**, 3, August, 1932.
5. Filtration of plant viruses. *Nature*, **130**, August 13, 1932.

19. BIOLOGICAL FIELD STATION, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

Entomological Work.—This work has been mainly concerned with the study of the problems arising in the rearing of large stocks of insects, chiefly moths of the genera *Ephestia* and *Plodia* and beetles of the genera *Oryzaephilus* and *Tribolium*. Very large numbers of the different stages of development, egg, larva and pupa, of these insects are required for experimental work in fumigation. The problems which have arisen concern the viability of eggs, variation in the fertility of adult moths, and variation in resistance to fumigant gases of the stages of development of these insects. Low percentage viability of the eggs of *Ephestia kuhniella* has been shown to be a result of the rearing of moths at temperatures above 25° C., and it has now been proved that this is brought about by delayed spermatogenesis in the males. The sexually immature males pair with the females but the eggs produced following such pairing are frequently infertile ; histological and cytological evidence in support of this is now available. An account of the pairing and process of fertilisation in the moths of the genera *Ephestia* and *Plodia* has been published (1), and the results of the experimental work showing the extent of infertility occurring in *Ephestia* reared at 27° C. are ready for publication. An account of the histological and cytological work done in this field will shortly be prepared for publication.

Work on the resistance of insects to lethal agencies, such as cold, heat and poisonous gases, has shown that several forms of resistance occur and that the reactions of insects to these three lethal agents are different. Thus eggs of *Ephestia kuhniella* are most resistant to high temperatures on the third day of development. The period of development is normally between 5 and 8 days. Work on the resistance of insects to poisonous gases has confirmed results quite recently published by Cotton (*J. Econ. Entom.*, **25**, 5) who, however, has given no data relating to the egg stages. The most important of these results is that insects reared at different temperatures show different degrees of resistance to fumigants ; thus insects reared at 50° F. are more resistant to fumigants, such as ethylene oxide, than insects reared at 70°F. although the temperature during fumigation is 70° F. These results are of very great practical importance and have been especially useful in assessing the results of practical fumigation on a commercial scale.

Experimental work on the rearing of *Ephestia elutella* and *E. cautella* has been carried out and the various requirements of the three species, *E. elutella*, *E. cautella* and *E. kuhniella*, as regards temperature and humidity should shortly be available. This work is of special importance in determining the conditions required to reduce infestation in warehouses and stores. There is already some evidence that humidity is of more importance to *Ephestia elutella*

and *E. cautella* than to *E. kuhniella*. A beginning has been made in the study of insect respiration and its bearing on resistance to fumigants.

Mycological work.—A survey of cocoa arriving at Liverpool has been completed. The results of the survey show that cocoa arrives in England dry enough to prohibit growth of cocoa fungi; that Gold Coast cocoa is more mouldy than Nigerian cocoa and that germinated cocoa is much more prone to mould attack and to insect attack than sound ungerminated cocoa. The report also indicates that further work on storage conditions both in West Africa and in this country is desirable. The following species of fungi not previously reported as cacao saprophytes were found during the survey: *Aspergillus gracilis, A. repens, A. ruber, A. sydowi, A. terreus*; *Syncephalastrum cinerium, Scopulariopsis* sp., *Sporotrichum flavicans* var., *Penicillium citrinum* (or var.), *Actinomyces cacaoi*, I, II and III, *Cylindrocarpon* (*Fusarium*) sp. An account of this work has been published (2).

For the proper identification and classification of the mould fungi found in the course of this work it was necessary to undertake a study of their taxonomy and physiology. In this work special attention has been given to the *glaucus* and *gracilis* groups of *Aspergillus* and good progress has been made. Some work had already been carried out in the laboratory on the *Aspergilli* with reference to lipase production of strains isolated from stored copra and cocoa. An account of this work has been published (3). From Nigerian cocoa three *Actinomyces* were isolated which had not before been found in cocoa from that country. They were submitted to Dr. Waksman of New Jersey, who reported that they comprised three strains of *Actinomyces cacaoi*, a hitherto undescribed species. A short description of these strains has been published (4).

Chemical work.—The chemical work of the laboratory has been concerned mainly with fumigation problems. Present day fumigation practice is unsatisfactory because too little attention has been given to the kind of insect material used in experimental tests on fumigants, and no serious attempt has been made to study the behaviour of the gases during the actual process of fumigation.

With regard to the insect problem an extensive series of tests have been made both in the laboratory and in the course of commercial fumigation. These tests show that temperature has a very important effect on the resistance of insects to fumigants, and that the variation in resistance to fumigants of different insects and of the same insect at different stages of development is much more important than has been supposed. Another important factor relating to the kind of insects used is the high degree of infertility which frequently occurs in the eggs of the *Phycitid* moths used in fumigation. To overcome this difficulty it has been found necessary to use from three to four thousand eggs in the large-scale experiments.

The work on the behaviour of gases during fumigation has made good progress. An improved method for the measurement of the concentrations of fumigants in the gaseous state has been devised and subjected to severe tests, both in the laboratory and in commercial practice. The apparatus is a modification of the vacuum bottle. Of the three improved forms, that embodying the fracture of a glass septum by a current through an electromagnet has been found entirely satisfactory in practice and has been standardised. A modification of this apparatus, required when sampling air containing ethylene oxide, has been made and has proved entirely satisfactory. The actual working of the apparatus has been tested and possible errors inherent in the vacuum method have been studied in the case of two important fumigants, hydrocyanic-acid gas and ethylene oxide. By the use of this apparatus valuable data regarding the behaviour of gases during fumigation have been obtained which show that low temperatures, absorption by the products themselves and by other materials such as wood-work, and also leakage, are much more important factors in reducing concentration than is generally recognised. By the use of this apparatus in combination with test-insects the efficiency of a process of fumigation can be readily ascertained. It may now be claimed that practical fumigation is placed on a scientific basis. A description of the apparatus and its use has been published (5).

An important aspect of fumigation work is the determination of the concentration of fumigants both in air-spaces and in foodstuffs, and work has begun with special reference to ethylene oxide and hydrocyanic acid gas. The work on hydrocyanic-acid gas is not yet completed but improved methods of determining ethylene oxide have been devised. Experiments with the original method proposed by Deckert for the determination of ethylene oxide have shown that this does not account for more than 90 per cent. of the substance employed. The use of a nearly saturated solution of magnesium chloride instead of sodium chloride has been found to give results approaching the theoretical. Improved methods of handling the oxide, coupled with more careful standardising of the technique of determination, have resulted in closer agreement than that obtained by Deckert. This has greatly facilitated interpretation of the results. The application of these reactions to practical tests has been studied and a method for the estimation of ethylene oxide in the control of practical fumigation has been developed. An account of this work has been published (6).

Apart from research under the general programme of the laboratory two special investigations have been carried out on behalf of the tobacco industry and the furniture industry respectively.

The tobacco investigation has been in progress for three years and during the past year special attention has been given to the control, by means of low temperature storage, of *Ephestia elutella* nfesting tobacco. A report on the work up to date has been com-

pleted and will, it is hoped, be published shortly by the Empire Marketing Board. The cost of this investigation has been borne by the Southern Rhodesian Government and the Imperial Tobacco Company.

Titles of papers issued during the year.

1. Norris, M. J.: Contributions towards the study of insect fertility—I. The structure and operation of the reproductive organs of the genera *Ephestia* and *Plodia* (*Lepidoptera, Phycitidae*). *Proc. Zool. Soc. Lon.*, Part 3, 1932.
2. Passmore, F. R.: A survey of damage done by insects and moulds to West African cacao before storage in Europe. *Bull. Imp. Inst.*, **30**, 3, 1932.
3. Eyre, J. C.: Cultural studies of the *Aspergilli* with special reference to Lipase production of strains isolated from stored copra and cacao. *Ann. Appl. Biol.*, **19**, 3, 1932.
4. Bunting, R. H.: Actinomyces in cacao-beans. *Ann. Appl. Biol.*, **19**, 4, 1932.
5. Page, A. B. P.: The measurement of gas concentrations for the control of fumigation. *J. Soc. Chem. Ind.*, **51**, 46, November, 1932.
6. Lubatti, O. F.: Determination of ethylene oxide. *J. Soc. Chem. Ind.*, **51**, 44, October, 1932.

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20. PLANT PATHOLOGICAL LABORATORY, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

The general work on questions of Plant Pathology for Scotland is carried on at this Laboratory. Research is undertaken as far as the exigencies of general work permit and is carried out in co-operation with the Agricultural Colleges.

Specimens of diseased plants received at the laboratory during the year represented 200 separate diseases. Many of these troubles required a certain amount of research work as they are sometimes new, frequently uncommon, obscure or in an unusual form (2).

Bracken disease investigation.—During the winter months considerable progress was made in the study of the fungi isolated from diseased bracken. The identity of the *Corticium* causing one type of disease was established and the fungus was named *Corticium anceps* (Bres. et Syd.) n. comb. The life history of the *Mycosphaerella* sp. commonly associated with another type of disease has been fully investigated. Preparations were made for extensive field work and infection experiments during the summer, but the grant for expenditure was cancelled at the end of March and consequently this work was never carried out. (6, 7).

Diseases of Ornamental Plants.—Many cases of diseases on ornamental plants are examined for the horticultural trade. Two of these were investigated in this Laboratory by Dr. Gregor and Miss C. Burt, B.Sc., and the results will shortly be published. The former studied a disease of cherry laurel caused by *Trochila lauro-cerasi*,

while the latter was occupied with a disease of sweet williams and carnations due to *Heterosporium echinulatum*. In both cases some interesting new facts concerning the life-histories of the parasites have been brought to light.

Leek disease.—A *Phytophthora* disease of Leeks known as white-tip, named by Dr. Foister, *Phytophthora porri* nov. sp., in 1929, has been under investigation for three years. Field experiments are in hand on the relative susceptibility of varieties, and on the effect of sprays. The cultural work on the fungus in the laboratory is being carried out by Dr. Foister in connection with a general study of *Phytophthora* diseases. (3).

Seed-borne diseases.—In collaboration with this laboratory further work on seed-borne diseases is being carried out by Miss Noble in the Mycological Department of the University of Edinburgh. A short list has been published and further experiments and observations are in progress. (1).

Strawberry disease research.—The field trials of strawberries in infected land have been continued. No chemical has been found that will really clear the disease from infected soil. Further trials are still being carried out with one or two chemicals, but, as in the case of wart disease, resistant varieties appear to be the most promising line of progress. Variety trials are in progress and there is a marked degree of difference in resistance to the *Phytophthora*.

In the Laboratory, work has been continued on the fungal organism. The various stages of development of the oospore are being sought and the fungus appears to be a large *Phytophthora* having both an amphigynous and a paragynous mode of fertilisation.

Titles of papers issued during the year.

1. Alcock, N. L.: Notes on common diseases sometimes seed-borne. *Trans. Bot. Soc. Edin.*, **30**, 4, 332–337, 1931.
2. Alcock, N. L., and Foister, C. E.: List of fungous diseases received by the pathological department of the Department of Agriculture for Scotland. *Ibid.*, **30**, 4, 338–350, 1931.
3. Foister, C. E.: The white-tip disease of leeks and its causal fungus *Phytophthora porri* n. sp. *Ibid.*, **30**, 4, 257–281, 1931.
4. Foister, C. E.: The relation of weather to diseases of crop plants. Two synopses for Min. Agric. Publ. on agric. meteorology, (In Press), 1932.
5. Gregor, M. J. F.: A study of heterothallism in *Ceratostomella pluriannulata*, Hedgcock. *Ann. Mycol.*, **30**, 1, 2, 1932.
6. ————: The possible utilisation of disease as a factor in bracken control. *Scott. For. Journ.*, **46**, 52–59, 1932.
7. ————: Observations on the structure and identity of *Tulasnella anceps.*, Bres. et Syd. *Ann. Myc.*, **30**, 463–465, 1932.

21. SEED TESTING AND PLANT DISEASE DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Seeds.

Ultra-violet light tests in connection with purity of ryegrass species and strains.—Enquiries were continued into the practicability of the ultra-violet light test for ordinary routine work, principally with ryegrasses. It was found that among the commercial samples of perennial ryegrass received for routine testing there was relatively small variation in proportion of fluorescent individuals. The majority of samples showed a proportion of fluorescent seedlings approximating to 10 per cent. and variations of more than 2 or 3 per cent. on either side of this average were unusual. The explanation of this is probably to be found in the mixing of crops and stocks which takes place during cleaning and bulking for distribution and in the relative absence of special brands and strains of this species, as well as in the fact that awned ryegrass, if present in a perennial sample to a material extent, is easily visible and seed growers refuse samples for sowing which are obviously contaminated with Italian.

In the case of commercial Italians much greater variation was found ; here the percentage of non-fluorescent seedlings varied from 1 or 2 up to nearly 50 per cent. and by applying the rule that an awnless seed giving a non-fluorescent seedling is perennial, it appeared that a considerable number of commercial Italians contained more than 15 per cent. of perennial and were thus, under British regulations, to be classed technically as mixtures. From the results of 100 samples there appeared to be a rough correlation between proportion of awnless seeds in Italian samples and percentage content of perennial, in spite of the recognised facts that Italian seeds are not invariably awned and that awns are lost during machining. A number of samples of two selected Danish strains containing high percentages of awnless seeds proved, however, to be practically pure Italian. Graphs and details are embodied in a report upon this enquiry published in the Proceedings of the International Seed Testing Association (1).

The experiments upon the genetics of the phenomenon have been pursued to a further stage and three seasons' results are now to hand from which it seems safe to deduce that (i) the capacity to fluoresce is heritable, (ii) normally *Lolium perenne* is pure for non-fluorescence and *Lolium multiflorum* for fluorescence, (iii) fluorescence is dominant in the F_1 generation of the cross pure fluorescent X pure non-fluorescent, (iv) the F_2 generation gives a ratio not significantly differing from three fluorescent to one non-fluorescent, (v) the back cross F_1 X pure fluorescent gives all fluorescent progeny and the back cross F_1 X pure non-fluorescent gives a ratio approximating to one

fluorescent to one non-fluorescent, (vi) no genetic linkage has been found between fluorescence and (*a*) the possession of awns on the lower flowering glumes (*b*) shoot vernation, (*c*) longevity (data limited) or (*d*) vigour (data limited).

The findings are being studied with a view to formulating a hypothesis capable of explaining the fact that *L. perenne* strains as a whole have a striking correlation between agronomic value and content of fluorescence reactors.

Indigenous strains of grasses and clovers.

(i) *Strains already purchasable.*—The farm scale plots referred to in last year's report, sown with indigenous grasses and clovers in 1929 and 1930 have continued to give excellent results; hay weights from the latter in 1931 were equivalent to crops of about 2 tons per acre in spite of the strains being pasture strains.

(ii) *New strains.*—A collection of long-lived strains naturalised in Northern Ireland pastures was made during the summer of 1931 by fencing off and harvesting plots of selected old pastures varying in age from 4 or 5 to over 50 years, and in one case from Roe Island in Strangford Lough, upon which cattle are grazed but not " artificially " fed, and which has not been under cultivation for some generations. Half-pound samples of seed dressed from these collections, together with selected foreign strains of repute and commercial samples (in all some 47 lots), are being sown at the Agricultural Research Institute for Northern Ireland, Hillsborough, for the purpose of appraisement by means of " grazing " (lawn mower), hay and seed production tests.

Weeds.

Sodium chlorate as a weed killer.—Further trials have been made with sodium chlorate as a weed killer for arable ground with encouraging results. *Bracken* on sandy links was, for practical purposes, extirpated by one autumn dressing at 200 lb. of chlorate per acre. *Stinging nettle* was completely killed, in several trials, by a similar dressing, and would probably succumb to smaller dressings. *Coltsfoot* responded well to doses of about 2 cwt. per acre. *Gorse*, although at first apparently seriously injured, recovered, probably because of its great root depth.

Trials are now in hand with a cheaper form of chlorate which contains about 50 per cent. of sodium chloride.

Charlock treatment.—Duplicate trials in 1931 of a proprietary nitrogenous copper weedicide, Green Vitriol at 7 per cent., and the usual copper sulphate solution, failed to show any advantage in favour of either of the first two named.

Plant Pathology.

Potato diseases.

Ordinary or late blight (*Phytophthora infestans* de Bary).—The series of experiments being carried out with a view to determining

the varying degree of susceptibility to blight of haulms and tubers of potato varieties grown in Northern Ireland has been continued, and a report of the work is being prepared for publication. The value of " earthing-up " as a control measure for tuber attack is also being investigated.

Comparative spraying trials using Burgundy mixture and a proprietary colloidal copper fungicide have been made during the year, but further trials will have to be conducted before any satisfactory statement of results can be made.

Pink rot (*Phytophthora erythroseptica*, Pethy. and Murphy).—Five years' investigational work dealing with both the laboratory and field aspects of this disease have been concluded and the results are ready for publication. It has been shown that the causal organism is widespread and that pink rot as a storage disease may be a more serious problem than its occurrence in the field. That the attack of the mother tubers at the time of planting may cause " misses " to occur in the crop, and also result in the occurrence of the " pink rot wilt " stage of the disease, has also been shown. The modes of perennation of the fungus and transmission of the disease have been studied. In the course of an investigation of varietal susceptibility it has been shown that none of the potato varieties examined can be classed as very resistant. Control measures should be focussed on (*a*) the use of well sprouted " seed," (*b*) the efficient drainage of the soil, (*c*) the avoidance of delayed digging, and (*d*) the construction of well ventilated " clamps," the tubers being first covered with a layer of rushes or herbage and not allowed to make contact with the soil used for covering. The debris of the dead haulms of a previous crop is believed to constitute a major factor in assisting the perennation of the fungus and this, coupled with a short rotation, is believed to be the cause of the disease occurring in epidemic form, especially in wet seasons.

Disinfection of tubers.—The question of the value of disinfection of tubers, and especially those to be used for seed purposes, as a general precaution against disease, is being studied. Trials involving the use of well-known fungicides and proprietary materials were carried out during the year but no definite statement can yet be made.

Flax diseases.

The results of seed disinfection experiments carried out with the object of controlling seed-borne diseases have not given results in favour of disinfection. These diseases of flax have not been of economic importance generally during the past five seasons, and the reason for this is believed to be in the employment of a lengthened crop-rotation consequent upon the big decline of the flax acreage.

Oat diseases.

The results from the general seed disinfection experiments carried out at the Agricultural Research Institute for Northern

Ireland, Hillsboro', County Down, have been published (2). The use of organic mercurials for seed disinfection is gaining ground in the country and in the course of a few years will undoubtedly become established as general practice. Results from the work carried out in 1932 are not expected to show so much in favour of disinfection as those obtained in previous seasons. This is held to be due to the excellent weather conditions which resulted in the general harvesting of a very good crop. The range of proprietary materials under test was extended during the season, and work planned with the object of determining the *modus operandi* of seed disinfection is in progress.

The chain of field experiments being carried out in collaboration with the County Instructors in Agriculture was continued for 1932.

Fruit diseases.

Apple scab (*Venturia inaequalis Aderh.*).—Apple scab was less severe in 1932 than in any other season since 1923. Orchards in general were well sprayed and a good crop of clean fruit was gathered. Excess lime Bordeaux mixture *versus* a proprietary colloidal copper spray and colloidal sulphur was tested during the season, and it is intended to continue the experiment over a period of years.

Six apple manurial experiments were laid down in 1932 on the bases of the results obtained from the Dunadry experiments (County Antrim), which have been in progress since 1929. The Dunadry crop for 1932 was disappointing, but it is hoped that in the course of time adequate data will be obtained from the six additional centres. Continued collaboration with regard to the interpretation of the results obtained has been arranged with the Department of Botany, Imperial College of Science, London.

Leather rot of strawberries (*Phytophthora species*).—This disease was not recorded for 1932, but a considerable amount of laboratory work has been carried out in connection with the identification of the isolation made in 1931.

Rose diseases.

Rust (*Phragmidium mucronatum* (Pers.) Schlecht).—A commencement has been made in connection with securing the control of this disease, and during 1932 a series of summer spraying trials were conducted. Colloidal sulphur and soft soap gave promising results and a progress report of the experiment has been written for publication.

Finger and toe of Brassicæ.

The results of a trial dealing with the control of this disease in broccoli have been published. Very satisfactory results were obtained by the use of mercuric chloride at the time of transplanting, which is in accordance with those already recorded by other workers.

Forest tree diseases.

Further experiments dealing with the use of sulphuric acid and aluminium sulphate for controlling diseases and weeds in the forest nursery have been carried out.

Mycology.

A further annotated list of additions to the fungus flora of Ulster is being prepared for publication in 1933.

Economic Entomology.

Apple tree pests.

Winter washes.—The work on the winter spraying of fruit trees which has been in progress for some time was extended this year to include a series of trials conducted in County Antrim. Various proprietary and home-made spray fluids were used and their comparative merits were assessed.

Capsid bugs.—An experiment was arranged to determine the value of the use of mineral oil emulsions and combinations of them with tar distillates, for securing control of these pests under conditions prevailing in Northern Ireland. The work was undertaken in County Armagh, where 23 different treatments were applied as " dormant " and " delayed dormant " sprays.

Red spider.—Investigations of the methods likely to prove most suitable for controlling red spider were made in County Antrim. A series of treatments very similar to those used in the apple capsid experiments was employed and, in addition, summer spraying was carried out with sulphur and pyrethrum compounds.

Blackcurrant pests.

Blackcurrant mite.—Experiments involving the use of polysulphide spray fluids, colloidal sulphur and dusting sulphur were carried out at three centres. The main factors considered were the concentrations at which the insecticides could be safely applied, the number of applications necessary to secure control, and the optimum dates for application.

Vegetable pests.

Cabbage root fly and carrot fly.—Similar experiments designed to indicate the most suitable control measures for employment against these pests were carried out at two centres in County Down. The insecticides used included flake naphthalene, mercuric chloride, a weak solution of a tar distillate wash, and creosoted chalk dust.

Titles of papers issued during the year.

1. Linehan, P. A., and Mercer, S. P. : Purity of British commercial Italian ryegrasses. *Proc. Ninth Conf. Seed Analysts, N.I.A.B., Cambridge,* 1932.
2. Muskett, A. E., and Cairns, H. : The effect of seed disinfection upon the oat crop in Northern Ireland. *Ann. Appl. Biol.,* **19**, 462–474, 1932.

E.

AGRICULTURAL PARASITOLOGY.

22. INSTITUTE OF AGRICULTURAL PARASITOLOGY, LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE.

Parasites of sheep and goats.—Of late years the importance of grassland has greatly increased in this country and the " New System of Grassland Management " is now carried on in many centres. This method implies intensive grazing by stock on small areas followed by periodic dressings of the plots with nitrogenous manures. Although the system increases the stock-carrying capacity of the land, the possible danger from helminths as the result of certain factors inherent in the method of management, is not realised. This problem is now under study on field plots at Winches Farm. Dr. Morgan has made a series of comparisons of the worm burden of animals under the " New System " with that found in stock grazing over larger areas. The experiment is, however, complicated by numerous factors, usually met with in field experiments, which cannot be controlled. An example of this is the weather factor during this spring, which has prevented stock being put out on the grass before the latter has become too long. Many factors are involved in the " New System " which may have a considerable influence on the concentration and viability of worms on grassland and thus have a great effect on the health of domestic animals. These factors include heavy stocking, close grazing, rotational grazing, the use of " followers," the effect of artificials, the periodic rests for each area, as well as weather and seasonal influences.

Parasites of pigs.—Some preliminary experiments have already been made on ascariasis in pigs and some interesting results have been obtained on the question of immunity in relation to age of host and to previous infections with ascaris. These experiments are being continued together with observations on other helminths of pigs.

Parasites of poultry and domestic birds.—In view of the great extensions now being made in the poultry industry, a study of the parasites of birds becomes increasingly important. During the last two years, a good deal of attention has been paid to these hosts and particular studies have been made on the capillarids and the gape-worms. The importance of wild birds as reservoir hosts of helminths found in poultry and in partridges and pheasants is under consideration, while attention is still being given to the role played by starlings as distributors of " gapes." With regard to the capillarids it has been found that much work of a purely systematic nature is necessary before any observations can be made on the importance of these forms to the poultry industry.

During the past year, under a grant from the Medical Research Council, Miss P. A. Clapham, B.Sc., has been attached to the Institute to investigate the possible effect of diet on the prophylaxis

of helminthiasis. Previous work in this line has suggested that the vitamins have a powerful prophylactic reaction. Ackert in America found that vitamin A was instrumental in significantly reducing the numbers and lengths of certain intestinal nematodes in the chicken. Vitamin B reduced the numbers significantly. Hiraishi, working on swine ascaris, also found that vitamin A affected the infectivity of the eggs and was able, by careful consideration of the vitamin constitution of the diet, to bring about the infection of pigs with the human strain.

These lines of research have been examined using, however, the cæcal nematode parasite of poultry—*Heterakis gallinæ*. An essential part of the work was an understanding of the structure and life-history of the parasite, so as, the more readily, to see into the nutritional habits of the worm. This species is a small worm, living in the debris of the cæca. Eggs are passed in the fæces and after undergoing a period of development in moist soil, become infective. If ingested by a suitable host, the larvæ hatch, pass direct to the cæca and undergo their complete development in the lumen. At no stage of their life-history do they become actual tissue parasites. Their food is always taken from the ingested debris.

The results were unexpected as they in no way bore out results already published. In the case of this cæcal worm, vitamin A has no effect on its infectivity or its development.

The reason for this difference is probably to be found in a deeper consideration of the habitat and life-history of the parasites. *Ascaridia lineata* for the first three weeks of its life is a parasite of the tissues, while *H. gallinæ* is always confined to the lumen of the cæca.

As *Heterakis gallinæ* has been recorded from a large number of hosts, the presence of physiological strains, associated with definite hosts was not unlikely. Material was therefore collected from the pheasant, guinea-fowl and turkey and this was fed to various chicks. To half of each group was fed a diet low in vitamin A and to the other half the same diet plus an extra ration of vitamin. At autopsy, the chicks which had adequate vitamin harboured fewer worms than the others, but in no case was the difference significant.

From the results obtained from these two sets of experiments it is not possible to say that vitamin A has any effect on the infectivity or growth of the cæcal parasite *H. gallinæ*. From the evidence obtainable so far, the scope of vitamin A in the prophylaxis of helminthiasis would seem to be limited. A direct effect would seem to be found in the tissue stage of *Ascaridia lineata*, but there is no evidence that a similar result is effected on *H. gallinæ*.

Parasites of vermin.—A considerable mortality among wild rabbits has recently been associated with infestation of the liver with a species of *Capillaria*. Dr. Morgan has shown by laboratory experiments that this parasite is identical with *Capillaria hepatica* which has been reported hitherto from wild rats (6).

Field mice have been studied by Dr. Morgan for some years past as possible reservoirs of helminth infection, and he has now described and differentiated *Oxyuris stroma* Linstow 1884 (5).

Parasites of economic plants and weeds.—Since the establishment of the Institute of Agricultural Parasitology with its field station at Winches Farm, St. Albans, Dr. T. Goodey has carried out numerous investigations on plant-parasitic and related nematodes. Particular attention has been devoted to the parasitic species, *Anguillulina dipsaci—Tylenchus dipsaci*, which attacks a wide range of plants, many of which are important agricultural crops such as red clover, potatoes and oats, whilst others are valuable garden plants such as onions, narcissi and phloxes. For some time past the attacks of this parasite on potatoes, mangolds and carrots have been under investigation and several new hosts have been discovered (1). Dr. Goodey has also contributed papers on little known eelworm parasites (2 and 3).

In June, 1932, Dr. Goodey monographed the whole genus *Anguillulina* vel *Tylenchus* which contains about 20 species parasitic on plants, some being of great agricultural and horticultural importance (4).

The differentiation of parasitic species from semi-parasites and saprophytes is constantly necessary and in this connection the specialist knowledge gained in the Institute is frequently requested by outside workers seeking expert opinion on these matters.

The practical aspects of plant-parasitic nematodes have also received much attention and field scale experiments have been carried out at Winches Farm. Plots devoted to the study of *Anguillulina tritici* on wheat and *Anguillulina dipsaci* on potatoes have been established in order that problems connected with these parasites as they appear on the farm may be investigated. Particular attention has been paid to the question of what varieties of potatoes are susceptible to attack by *Anguillulina dipsaci* and to the problem of the persistence of the parasite in the field.

Attempts have been made to establish this same parasite on the field in two other agricultural crops on which it is a serious pest, namely, oats, in which it causes " tulip root " and red clover, in which it causes stem disease. So far, unfortunately, these attempts have proved unsuccessful for reasons which are not immediately apparent and it has been forcibly brought home to us that it is no easy matter to bring in the parasite from afar and establish it as a pest, even on the appropriate host plant, in a new environment.

The experience gained from these attempts has been valuable in spite of the disappointment and apparent failure involved, and points to the need for further investigations on the bionomics of the parasite. Information is especially needed on such questions as the sporadic appearance of outbreaks of " tulip root " in seedling oats and stem disease in clover, linked up, as the last is, with the

general problem of " clover sickness." This year studies are being made on the ecology of the parasite and its host or hosts and the question of weeds as reservoir hosts comes in here and the susceptibility to attack of the previous crop or crops.

For several years past, Miss M. J. Triffitt, D.Sc., has concentrated her attention almost solely on the eelworm *Heterodera schachtii*, the causative organism of " beet-sickness," a disease which was responsible for the closing of many beet-sugar factories in Germany, France, Holland, and Austria. In 1917, this parasite was first reported to be parasitising potatoes in Yorkshire, and since this date it has been found to be distributed over the majority of the best potato growing land in Britain, rendering much of it incapable of producing a profitable crop.

In 1926, extensive field observations were carried out by Dr. D. O. Morgan in South Lincolnshire, one of the worst affected areas. Dr. Morgan surveyed the problem as a whole, establishing the part played by the nematode in the production of disease symptoms and investigated the effects of various manurial treatments and crop rotation. Dr. Triffitt has continued Dr. Morgan's work. Fundamental researches into the morphology and bionomics of the parasite showed that, although only a single species was responsible for the damage to beet, oats, wheat, peas, etc., on the continent of Europe and potatoes in Britain, the specialisation of the parasite to its different hosts resulted in the formation of " biological strains " which showed such diversity in their physiological reactions that each required individual investigation. Thus, experiments giving positive results in Germany were found to give negative results with the potato strain prevalent in Britain. Bionomical investigations were therefore extended to cover the life-history and physiological reactions in the British potato-strain, and similar investigations are now being made on strains attacking other plants of agricultural importance in Britain.

Special attention directed to the influence of the root excretions of plants immune to attack have resulted in the laying down of large scale field experiments in Lincolnshire planned to extend over a period of three or four years. The first season's results obtained from these experiments proved satisfactory, and in this, the second year, the experiment is being watched (9).

Although *Heterodera radicicola* is usually a hot-house parasite in this country, its occurrence in the field was reported from several areas last year, and were investigated by Dr. Triffitt (7).

Parasites of insect pests.—Dr. Oldham's research activities have been mainly centred upon the relationships between helminths and insects. In this connection the work has fallen into two classes :— (1) the investigation of parasites of insects where the insect acts as a primary host, (2) the investigation of helminths which are found naturally or experimentally in insects when the insect acts as a vector of the parasite. The first type of investigation has been

carried on more actively than the second, as the species of insects being dealt with are of importance economically.

At the present time the investigation of a nematode parasite of flea-beetles is being carried out. These beetles, which belong to the genus *Phyllotreta*, are mostly pests of cruciferous crops and serious damage may be done to turnips, radish and cultivated brassicæ by the adults in two periods of attack, the first in spring by the over-wintering beetles and the second in the late summer by the new generation. The spring attack is more important economically as the plants are then in the seedling stage.

Up to the present five species have been under investigation. Of these it has definitely been established that *P. nemorum* L. is free or practically free from nematodes, a fact easily accounted for when its mode of life is considered. In the remaining species the percentage of parasitism varies somewhat and a large number of dissections have so far yielded the following data :—The most heavily parasitised species is *P. undulata* Kutsch., which has a 74 per cent. infestation, *P. atra* Fabr., with 11.4 per cent. follows, then *P. nigripes* Fabr., with 10 per cent. and *P. cruciferæ* Gœze with 2.4 per cent. *P. vittula* Redtb., has not provided reliable data owing to insufficiency of material.

Some stages in the life cycle of the parasite have been studied. It is hoped during the coming season to complete the knowledge of the life-history and to study in detail the effect of the parasite on its host species which, so far as can be judged, appear to suffer as many other insect hosts do by having their reproductive organs reduced in size and in some cases rendered sterile. Such a form of biological control may be of great importance when the widespread destructive propensities of these flea-beetles are considered in relation to agricultural crops.

The reduction of insect damage throughout the country is of primary importance owing to the extensive damage done to agricultural crops by these pests. While a number of reliable methods, known to entomologists, by which this reduction may be effected are applicable, such as mechanical and chemical control in the form of spraying, fumigation, and so on, it has become increasingly apparent that these are costly and provide many difficulties. Coincident with this realisation, the knowledge gained from preliminary experimental work has shown that biological control is not only effective but presents fewer difficulties and is in the long run less costly. The use of parasitic insects to combat crop pests is becoming more and more extensive, but the majority of entomologists, owing to a lack of knowledge of helminthology, are apt to overlook the possible importance of worm parasites.

While there are but few researchers working on this aspect of biological control, their work goes to show that our knowledge of helminth parasites of insects is gradually increasing in importance, and may prove to be of great value in supplementing the work of

parasitic insects. With these considerations in mind, it is intended that, in addition to the above-mentioned research work on the flea-beetles, examinations of other insect pests of agricultural crops should be made with a view to investigating particularly those found to be parasitised by worms. The study of the life-cycle of the parasites found along with the incidence of infection and the results of parasitism, will be the main considerations of future research so that reliable data on the amount of control which might be expected can be produced.

As the subject of biological control of helminth vectors is an almost unexplored field, incidental reference may be made to a paper in which Dr. Triffitt, in association with Mr. Buckley and Mr. McDonald, has described the lethal effect of a protozoan parasite on a molluscan carrier of Bilharzia (8).

Titles of papers issued during the year.

1. Goodey, T.: New hosts of *Anguillulina dipsaci* (Kühn, 1858) Gerv. and v. Ben., 1859, with some notes and observations on the biology of the parasite. *J. Helminth.*, **9**, 191–196, 1931.
2. ————: On the nomenclature of the root-gall nematodes. *Ibid.*, **10**, 21–28, 1932.
3. ————: Some observations on the biology of the root-gall nematode, *Anguillulina radicicola* (Greeff, 1872). *Ibid.*, **10**, 33–44, 1932.
4. ————: The genus *Anguillulina* Gerv. and v. Ben., 1859. vel *Tylenchus* Bastian, 1865. *Ibid.*, **10**, 75–180, 1932.
5. Morgan, D. O.: *Oxyuris stroma* Linstow, 1884. *Ibid.* **10**, 15–20, 1932.
6. ————: An experimental infection of the rabbit with *Capillaria hepatica* (Bancroft, 1893). *Ibid.*, **10**, 65-66. 1932.
7. Triffitt, M. J.: On the occurrence of *heterodera radicicola* associated with *Heterodera schachtii* as a field parasite in Britain. *Ibid.*, **9**, 205–208, 1931.
8. Triffitt, M. J., Buckley, J. J. C., and McDonald, W. A. On a new parasitic protozoon associated with a sickness in a bilharzian intermediate host. *Ibid*, **9**, 45–52, 1932.
9. Triffitt, M. J.: Preliminary note on the use of root excretions as a method of controlling the nematode *Heterodera schachtii*. *Ibid.*, **10**, 181–182, 1932.

23. DEPARTMENT OF HELMINTHOLOGY, DEPARTMENT OF ZOOLOGY, UNIVERSITY OF EDINBURGH.

Parasites of sheep.—The studies on the parasites of sheep were continued during the year both from the point of view of distribution and prevention. While a considerable amount of data as to the distribution and prevalence of the various species is now available, considerable research is still necessary before satisfactory means of prevention, which are both economic and practicable, can be evolved. A paper on this aspect embodying the results of experiments during the past two years is in preparation.

Fauna of Scottish wild mammals.—The studies on the fauna of Scottish wild mammals were continued intensively and a considerable number of parasites were collected, both personally and through the co-operation of game wardens and keepers. Three papers on this subject (2), (3) and (4) have already been published and a fourth (8) is in active preparation. The animals especially studied were wild carnivores, herbivores and rodents. The skeletons of a number of the animals collected have been presented to the Zoological Department of the University and form a useful addition to its teaching material.

Parasitic lung diseases.—The pathology of the parasites of the lungs has been studied during the year and two papers on this subject have been published. The condition is an extremely important one so far as the domesticated animals are concerned. The first paper (5) gives an account of all the parasitic lung diseases in Britain, while the second (6) deals with a species common in cats in the Edinburgh district.

Miscellaneous.—A number of examinations of fæces for the presence of parasitic worms has been made at the request of veterinary surgeons and others in Scotland. A meeting of veterinary surgeons in the south-west of Scotland was addressed during the spring on lung worms in stock and a paper (7) was contributed on "Helminthology in relation to Stock" at the symposium on Applied Helminthology at the British Association in York.

Titles of papers issued during the year.

1. Cameron, T. W. M.: The internal parasites of sheep: A survey. *Veter. J.* **88**, 4, 140–148, 1932.
2. ———————: Nematodes from the Scottish red deer. *J. Helminth*, **9**, 4, 213–216. November, 1931.
3. ———————: Parasitic worms of the Scottish red deer. *Proc. Roy. Phys. Soc.*, **22**, 2, 1932.
4. ———————: An Oxyurid from the grey squirrel in Scotland. *J. Helminth.*, **10**, 1, 29–32, 1932.
5. ———————: Lung worms of domesticated animals. *Veter. Rec.*, July 9, 1932.
6. ———————: Pathogenicity of the stomach and lung worms of the cat. *J. Helminth*, **10**, 4, 231–234. September, 1932.
7. ———————: Helminthology and stock. *Imp. Bur. Agric. Parasit.*, Notes and Mem., No. 7, 1932.
8. Cameron, T. W. M., and Parnell, I. W.: Parasites of wild mammals in Scotland. (In preparation.)

F

ANIMAL PATHOLOGY.

24. RESEARCH INSTITUTE IN ANIMAL PATHOLOGY, ROYAL VETERINARY COLLEGE.

Mastitis in Bovine Animals.

Different forms of mastitis and their bacteriology.—Investigations on the bacteriology of streptococcus mastitis have been continued throughout the year, and in order to obtain full advantage from this study the results have been considered in relation to the symptoms and course of the disease in affected animals. It has been found that mastitis streptococci, in respect of their cultural and biochemical characters, fall into three distinct groups, which for the purpose of description have been called Groups I, II and III. To these must be added yet another group of streptococci, which, although occurring less frequently, are of great importance because they have been proved to be indistinguishable from certain haemolytic streptococci from human beings. An account of these findings was embodied in last year's report.

Workers in the past have devoted attention almost exclusively to the streptococci designated Group I, because these are responsible for the chronic form of mastitis which is widely prevalent among milking cows. It has often been remarked, however, by observers in the field that mastitis is not invariably chronic in its course, but may sometimes be quite acute. It is known that acute relapses are liable to appear during the course of an essentially chronic infection caused by Group I streptococci, but research has made it clear that acute attacks are not infrequently dependent upon the presence of an entirely different variety of streptococcus, which has been called Group II. Group II infections, although less common than those due to Group I, sometimes assume great importance in practice, because the pathological changes may be so acute that the affected quarter is rapidly destroyed. At other times the attack, although acute in nature, is comparatively mild and rapidly yields to thorough and repeated milking, and subsequent bacteriological examination of the milk may no longer reveal streptococci. Group II infections appear to be derived from some other situation within the animal body, possibly from the uterus, and, so far as the observations in the Institute have gone, this form shows no tendency to spread by contagion.

Disorders due to streptococci of Group III are mild and transient and cannot be detected as a rule without making an examination of the milk in the laboratory.

A full account of this work has now been published (1, 2).

The serological characters of mastitis streptococci.—A serological analysis of mastitis streptococci, using agglutination and precipitation methods, is being carried out. Since, in a general way, streptococci do not readily lend themselves to this form of enquiry, a great deal of preliminary work on technique was necessary before results could be accepted. Up to the present, most attention has

been paid to streptococci of Group I, and this has shown that the group can be differentiated into not less than three main serological types. An attempt is now being made to ascertain the practical importance of these observations, of which an account has been published (3).

Diagnosis.—Work on this phase of the problem has been continued during the year, chiefly with a view to simplifying laboratory technique and to finding the extent to which it is necessary to resort to the laboratory for guidance. With regard to the first point, a culture medium has been developed which promises to be of value in two ways. Not only does this medium inhibit the multiplication of certain harmless bacteria which are present in udder milk, sometimes in large numbers, but also it enables certain other harmless bacteria and Group III streptococci to be differentiated from Groups I and II. Further, up to a point the medium permits a distinction to be made between Groups I and II.

Influence of mastitis upon the milk yield of cows.—This problem is being investigated in collaboration with the Department of Vital Statistics of the London School of Hygiene. The work involves a comparison of the recorded milk yields of groups of cows of the same breed and living under the same conditions and which are known to be free from other contagious diseases to which cattle are liable, such as tuberculosis and abortion. In time, it is hoped to obtain a large and comprehensive set of figures from which deductions of real value may be drawn.

The possible influence of cold flooring upon the incidence of mastitis.—It is commonly believed that cold wet flooring predisposes cows to attacks of udder disease. An enquiry on this point was instituted in a machine-milked herd, comprising about 160 cows, which had suffered considerable loss from Group II streptococcus infections, but which was, practically speaking, free from ordinary chronic mastitis. Between December, 1930, and March, 1932, approximately half the animals were stalled on concrete and half on a warmer flooring made of cork brick. A minimum amount of bedding was provided. During this period 26 cases of mastitis developed, of which 15 occurred in cows standing on concrete and 11 in cows on cork brick. The attack was sufficiently severe to cause clinical symptoms in 10 cows on concrete and 6 cows on cork ; with the remainder a diagnosis had to be made in the laboratory. The results cannot be held to indicate that a cold flooring such as concrete is an important predisposing factor in producing this form of mastitis.

Control.—Control measures inaugurated in 1929, involving the detection of cases which are not readily manifest, combined with the milking of all infected cows last, are being continued in six herds. Milk samples from the presumably healthy sections of these herds are submitted to laboratory examination at regular intervals of three months. Up to a point the results are encouraging and they

show beyond question that the incidence of chronic streptococcus mastitis can be greatly reduced by these measures. In one small self-contained herd Group I streptococci have not been encountered since March, 1931, and this goes to substantiate the working hypothesis that chronic streptococcus mastitis is spread by contagion from cow to cow. In general, it has been found, as would be expected, that it is more difficult to prevent spread in herds where the original incidence of infection was high and where most of the initially infected cows are allowed to remain on the premises.

Lectures and reviews.—In response to requests from various quarters, the present state of scientific knowledge of bovine mastitis has been reviewed (4, 5), and addresses on various branches of the subject have been given before veterinary societies (6, 7).

Titles of papers issued during the year.

1. Minett, F. C., Stableforth, A. W., and Edwards, S. J.: Studies on bovine mastitis.—V. The more acute forms of streptococcus mastitis. *J. Comp. Path. and Therap.*, **45**, 1, 1932.
2. Edwards, S. J.: Studies on bovine mastitis.—VI. The non-hæmolytic streptococci of mastitis and their relationship to certain saprophytic streptococci of cattle. *Ibid.*, **45**, 43, 1932.
3. Stableforth, A. W.: Studies on bovine mastitis.—VII. The serological characters of mastitis streptococci. *Ibid.*, **45**, 185, 1932.
4. Minett, F. C.: Les mastites de la vache. *Bull. de l'Office Internationa des Epizooties*, **6**, 124, 1932.
5. ————: Mastitis in the cow, ewe, goat and mare. *Encyclopædia of Veterinary Medicine and Surgery*. Revised Edition. (In press.)
6. ————: Bovine streptococcus mastitis and the public health. *Vet. Rec.*, **12**, 545, 1932.
7. Edwards, S. J.: The diagnosis of chronic streptococcus mastitis. *Ibid.*, **12**, 977, 1932.

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25. INSTITUTE OF ANIMAL PATHOLOGY, CAMBRIDGE UNIVERSITY.

Filterable Viruses.

Epithelioma contagiosum.—Investigations into several methods of vaccinating against fowl-pox and pigeon-pox have been completed (1). It has been found that emulsions of the virus rendered inert by heat, formalin or chloroform were capable of producing an immunity to the disease of only short duration, while products treated with phenol afforded a more durable protection. The vaccine of De Blieck and van Heelsbergen appeared to be identical with pigeon virus and was found to be of equal value in producing an active immunity when applied under suitable conditions. It was not found possible to demonstrate the presence of antibodies in the serum of recovered or of hyper-immunised birds.

Contagious pustular dermatitis.—The typing of strains of virus from different outbreaks has been continued. So far the evidence points to there being not more than one type. The application of complement fixation and precipitin tests has been considered with special reference to the elaboration of an *in vitro* method of determining the nature of crusts from unknown sources, so avoiding recourse to animal inoculations, and also to the detection of antibodies in the blood of recovered or hyper-immunised animals.

General Pathology and Bacteriology.

Classification of organisms of the B. welchii group.—The study of many strains of organisms of the *B. welchii* group as regards their morphological, cultural and toxigenic characters to which brief reference was made in an earlier report has been pursued (5). The classification of organisms falling within the group which was originally based upon cultural differences has been found to be unsatisfactory. By means of a comparison of the toxin-antitoxin relationship of a number of strains it has been shown that four distinct types can be recognised. These have been designated A, B, C, and D respectively. Characteristic differences have been shown to exist in the antigenic properties of their toxins. While the toxin of A is the simplest and its antigenic factors are shared by each of the other types, that of C possesses an additional factor which is shared by B but not by D. Similarly D possesses a factor also shared by B but not by C.

Further strains from various sources are being examined and typed as opportunity occurs.

Anaerobic infections.—Several instances of fatal disease in cattle due to *vibrion septique* have been investigated. It is of interest that in a number of fatalities in calves, infection would seem to have occurred without the presence of any visible wound. The strain of organism obtained from such cases has been found to possess an unusually high virulence for bovines.

Salmonella infection in calves.—Several outbreaks of this disease have been investigated in animals ranging from two weeks to 12 months of age in which the death rate was 61 per cent. The Dublin type of salmonella which may cause in man food poisoning, meningitis and continued fever with septicæmia, was found to be the causal organism in these outbreaks (2).

Sterility in the mare.—In the course of the routine examination of swabs taken from the *cervix uteri* of sterile mares the predominating organisms were found to be streptococci, a large proportion of which are of the hæmolytic type. A detailed study of a collection of these strains has been undertaken.

Contagious abortion of sheep.—Losses from abortion due to *Bact. abortus ovis* continue to be prevalent in many districts. To facilitate the detection of infection attention has been paid to (i) the prepara-

tion of a differential medium for the isolation of the organism from contaminated material, (ii) the extent to which agglutination of the organisms by sheep sera may be due to agglutinins which are not strictly specific and the possible elimination of such sources of error.

Pyobacillosis of sheep.—The study of the etiology of this condition as it affects home-bred sheep has been continued as opportunity occurs.

Fowl typhoid.—Experiments are being carried out to determine the viability of *B. gallinarum* in soil, water and excreta.

" Lactation-tetany " in cattle.—Several cases of this disease have been investigated and a bacteriological and bio-chemical survey of the condition has been made.

Immunity and Diagnosis.

Vaccination of calves against tuberculosis with B.C.G. vaccine.—In previous reports reference has been made to a selected method of immunising calves against tuberculosis with B.C.G. vaccine. It was shown that the double intravenous inoculation of the vaccine can confer a very high degree of resistance against a test dose of virulent bovine culture administered by the same route (3). Recent investigations (4) have shown that this method of immunising is capable of producing a complete immunity to the oral administration of virulent bovine cultures which produced moderately severe local and slight generalised tuberculosis in unprotected animals of the same age.

Experiments have been undertaken to determine (*a*) the period over which B.C.G. is recoverable from the bodies of calves after intravenous inoculation of the vaccine, (*b*) the duration of the immunity and (*c*) the possibility of reinforcing a waning immunity.

" Tuberculin."—The investigation into the preparation of various forms of " tuberculin " has been continued. As a result of tests applied with some 300 products on cattle, it has been possible to select certain preparations with which the non-specific reaction to the double intradermal test has been considerably less marked than is the case with " old tuberculin." An improved synthetic medium for the cultivation of the tubercle bacillus has been elaborated and is being studied.

A study has been made of the relationship of the glycerine content of veal broth employed in the preparation of tuberculin to the potency of the product (12).

" Johnin."—As a result of the experience gained with tuberculin, the investigation has been extended to include similar preparations for the diagnosis of Johne's disease.

Complement.—Various methods of preserving the complementary activity of guinea-pig serum have been investigated. It has been found that by the addition of sodium chloride and chinosol in suit-

able proportions, complement may be preserved in the cold for several months.

Toxicology.

An investigation of the physiological actions of taxine and of the toxicity of several varieties of yew has been completed.

It has been shown that the alkaloid taxine is absorbed only from the small intestine and is removed rapidly from the blood stream. It exerts a direct effect upon the heart, a solution of only one part in 500,000 producing a slowing of the rate and decrease in amplitude of the beat in a perfused heart. The most suitable physiological antidotes were found to consist of a combination of adrenalin, lobeline and barium chloride.

Many feeding experiments have been carried out with the less poisonous members of the order *Umbelliferæ* and a general survey has been made of the toxicity of these plants for small laboratory animals. Twenty-eight species have been examined. Only three members (*Cicuta virosa*, *Oenanthe crocata* and *Conium maculatum*) have been observed to produce toxic effects even when fed over considerable periods and constituting the main portion of the animals' diet.

Preliminary feeding experiments with certain members of the order *Ranunculaceæ* suspected of causing poisoning were carried out while the plants were available. Material has been collected for the steam distillation of 20 members of the order and the poisonous principles have been prepared for analysis. Plots of rye grass and *Ranunculus repens* have been laid down for feeding experiments.

Histology and Experimental Pathology.

"Blood tumours" in the fowl.—An investigation has been made into the etiology of "blood tumours" (*hæmangio-endotheliomata*) in fowls (11). In addition to the subcutaneous tumours growths have also been observed in various internal organs. The data were insufficient to show whether the involvement of these was the result of metastases or an example of a neoplasm with a multicentric origin. The White Leghorn breed appears to be especially liable to the condition and it is possible that the tumours are congenital in origin. Further work is being carried out on the transmission of the neoplasm and the possibility of hereditary predisposition.

A study of the vitamin C. requirements of the dog has been completed (9).

Biochemistry.

Investigation into the effects of nematode worms on the metabolism of sheep.—The first part of this investigation has been concluded and it has been shown that in heavy infestations the absorption of protein by the host is inhibited while that of carbohydrate and of fat is only slightly affected. An attempt is being made to ascertain the means by which the inhibition of protein absorption is brought about.

The effects of feeding mineral supplements on the chemical content of the blood of sheep.—The results of earlier experiments, carried out on hill farms in Northumberland on which the sheep are found to have a low blood calcium content, have been confirmed (7). It has been shown that the feeding of mineral supplements to in-lamb ewes increases their blood calcium and also raises that of their lambs to a level regarded as normal for lambs in other districts. Analysis of the milk of mineral fed ewes did not show a higher proportion of calcium than that of control animals. It would, therefore, appear that the higher blood calcium of the lambs was due to improvement in the calcium metabolism of the mineral fed ewes during pregnancy.

Biochemical studies of the blood of sheep.—The comprehensive survey of the chemical changes on the blood of ewes affected with pre-parturient and post-parturient forms of eclampsia has been continued. In an endeavour to reproduce the symptoms of these conditions artificially, a survey has been made of the action of various gland extracts and chemical substances (6).

Under normal conditions no significant change was observed in the calcium, phosphorus, sodium, potassium and sugar content of the blood of ewes during the last stages of pregnancy or in the first stages of lactation. There was, however, a marked increase in non-protein-nitrogen on the day preceding parturition and for several days after. The administration of guanidine nitrate had no effect other than a transitory hypo-phosphatæmia, while creatinine induced a slight degree of hypo-glycæmia. A more marked fall in blood sugar was observed after the administration of sodium chloride alone or in combination with guanidine nitrate or potassium oxalate, the greatest effect being produced with the last combination.

The injection of protein in the form of casein and egg albumin produced a severe hypo-glycæmia accompanied by a rise in the inorganic phosphate and some fall in calcium, while the potassium, sodium and non-protein-nitrogen showed no significant change.

The greatest effect was produced by bacterial toxins—in this case there was a rise in the blood sugar 24 hours after the subcutaneous injection of the toxin and for a variable time thereafter. Coinciding with this hyper-glycæmic phase there was an increase in the inorganic phosphate which varied in individual cases, and a fall in the blood calcium. The other constituents were not appreciably affected.

Only slight changes of a fleeting nature were observed after the administration of gland and other extracts such as parathyroid, anterior pituitary, ovarian and placental.

Calcium metabolism in sheep.—Considerable progress has been made in the investigation of calcium metabolism in relation to diseases in sheep. The effects of a low calcium diet on the metabolism of lambs and on the blood and bones of pregnant and non-pregnant ewes has received special attention.

Parasitology.

The study of the nematode worms of ruminants in relation to their environment with a view to establishing methods of control based upon the information so gained has been continued. Methods have been devised for the cultivation of the larval stages and adult worms in a medium similar to the usual habitat of the parasites.

Work on "blackhead" (*entero-hepatitis*) of turkeys has been pursued. Certain aspects of the disease have been further studied by tissue culture methods.

The life history of a filariid nematode found in the skin of horses associated with cases of "fistulous withers" has been investigated. An insect vector of this parasite has been found and its life history has been worked out. In the course of the search for other possible vectors observations have been made on the egg-laying habits of *Simulium* (13) and upon some other aspects of the biology of this and other species of insects.

Endeavours have been made to devise a more accurate method of determining the species of nematodes with which animals are infested and the degree of infestation.

As a result of extended trials with oil of chemopodium in the treatment of thoroughbreds and hunters infested with strongyles it has been found that this substance may be relied upon in most cases to remove the majority of the mature worms as well as trichonemas and allied species of worms when given in sufficiently large doses after proper preparation and accompanied by a purgative. The dose recommended for horses of three years old and upwards is from 4–6 drachms and for foals of over six months, 1 drachm. Larger doses did not appear to give better results (17).

Botany.

Preliminary spraying experiments have been carried out with several chemical substances with a view to the eradication of poisonous weeds from pastures. Results of a highly promising nature have been obtained in several instances.

During the year the garden of poisonous plants has been completed and contains specimens of many of the reputed poisonous varieties.

In addition to the educational part of the garden there is a working part in which the investigation into the strains of *Conium maculatum* has been continued. Seed of two types has been sent to two countries with widely different climatic conditions with a view to ascertaining whether the conine content is affected by climate.

The seed harvest from the garden has been considerable and a collection is being made for reference. A collection is also being made for the National Institute of Agricultural Botany and the surplus will be distributed to Botanic Gardens.

During the past year 14 cases of plant poisoning have been

investigated in various parts of the country, while many enquiries and specimens for identification have been dealt with.

Titles of papers issued during the year.

1. Glover, R. E.: Immunisation of the fowl and the pigeon against *Epithelioma contagiosum*. *2nd Rep. Direct. Inst. Anim. Path. Camb.* 1.
2. Bosworth, T. J., and Lovell, R.: The Dublin type of salmonella as a cause of disease in calves. *Ibid.*, 21.
3. Buxton, J. B., and Griffith, A. S. The use of B.C.G. in the vaccination of calves against tuberculosis. *Ibid.*, 28.
4. Griffith, A. S., Buxton, J. B., and Glover, R. E.: Further results of immunity experiments on calves with the B.C.G. vaccine. *Ibid.* 46.
5. Wilsdon, A. J.: Observations on the classification of *Bacillus Welchii*. *Ibid.*, 53.
6. Shearer, G. D., and Stewart, J.: Some biochemical studies on the blood of sheep. *Ibid.*, 86.
7. ————: The effects of feeding mineral supplements on the chemical content of the blood of sheep. *Ibid.*, 121.
8. Franklin, M. C.: The effect on the iodine content of (1) The thyroid glands, and (2) the blood of wethers and ewes when dosed with potassium iodide. *Ibid.*, 134.
9. Innes, J. R. M.: Vitamin C requirements of the dog: Attempts to produce experimental scurvy. *Ibid.*, 143.
10. Harris, L. J., and Innes, J. R. M.: The mode of action of vitamin D. *Ibid.*, 151.
11. Blakemore, F., and Innes, J. R. M.: A preliminary note on the "blood tumours" (*Haemangio-Endotheliomata*) in the fowl. *Ibid.*, 175.
12. Allen. H. R.: The relationship of glycerine in veal broth to the potency of tuberculin. *Ibid.*, 184.
13. Steward, J. S.: A note on *Simulium Sp.* attacking horses and cattle in Herefordshire. *Ibid.*, 194.
14. ————: Some nematode parasites of the British fallow deer (*Dama Dama*). *Ibid.*, 198.
15. ————: A list of parasites examined during the year. *Ibid.*, 200.
16. Wood, W. A.: Experiments on the treatment of parasitic gastro-enteritis in sheep and lambs. *Ibid.*, 204.
17. ————: Some notes on the treatment of equine strongylosis with oil of chenopodium. *Ibid.*, 212.
18. ————: Note on the size of the eggs of some species of sheep worms. *Ibid.*, 220.

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26. VETERINARY LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

FOOT-AND-MOUTH DISEASE EXPERIMENTAL STATION, PIRBRIGHT.

(Under the general direction of the Foot-and-Mouth Disease Research Committee).

Comparative tests have been made of a number of virus strains derived from British outbreaks, and considerable differences were recorded in the virulence of strains for particular species of hosts.

In each case the immunological type was determined, and, as in previous years, it was again found that the "O" type was most

frequently met with, but a number of results suggested that type differentiation is less simple or clear-cut than has been thought. Further work is in progress.

One strain of virus received from Kenya was found to be of the " O " type, and not to differ in behaviour from the strains commonly encountered in British outbreaks.

Samples of virus were also received from Southern Rhodesia. Owing to some unusual features in the Rhodesian outbreaks, these strains of virus were subjected to comprehensive tests, but under experimental conditions they resembled European strains in viability, resistance and general behaviour.

Further work was undertaken on the occurrence of the virus in the blood, urine and milk, and also on the survival of the virus outside the animal body, especially in the urine. With respect to resistance, and survival of the virus both in the carcase and outside the body, no significant difference was found in virus strains of different immunological types.

The duration of immunity in recovered cattle and pigs was further tested, and the work on immunity included potency tests of immune sera and observations of the effects on the serum of reinfections. The work recorded above has not yet been published.

Veterinary Laboratory, Weybridge.

Babesiasis and Anaplasmosis.—The strains from North and South Africa and South America were maintained. During the year two pedigree cattle (Guernseys) were immunised before export to British Guiana.

Consignments of ticks, with ova, were received from British Guiana, Jamaica, Kenya, Northern Rhodesia and Argentina. The ova were successfully bred out and placed on cattle, but up to the present time no infections with *Babesia* or *Anaplasma* have been established.

Contagious abortion of cattle.—During the year 21,877 doses of the living vaccine were prepared and issued, and 1,125 agglutination tests were performed in connexion with vaccination or attempts at eradication of the disease.

Work was continued in connexion with :—

(*a*) the duration of the infection set up by the living vaccine (1).

(*b*) the distribution of *Brucella abortus* in the body of the " carrier " cow ;

(*c*) the occurrence of different strains of *Brucella abortus*—in relation to the efficacy of the living vaccine ;

(*d*) the fluctuations in the agglutinating titre of bovine serum for *Br. abortus*, and the significance of low titres.

Field trials of certain killed vaccines were commenced.

Tuberculosis.

Bovine.—During the year 1,266 doses of B.C.G. vaccine were prepared and issued for trial in selected herds.

Avian.—Experimental work with an avian strain of B.C.G. vaccine was begun. Work was continued on the tuberculin testing of poultry, and further observations were made on the value of the test in the eradication of the disease from large and heavily infected flocks.

Lactation tetany in cows.—During the year numerous requests were received for help in connection with a disease (or possibly a group of diseases) passing under such names as " lactation tetany " and " cerebro-spinal meningitis ". Material from the field was submitted to extensive bacteriological examinations, and in two cases the cerebro-spinal fluid, collected shortly after death with satisfactory precautions, yielded a streptococcus in pure culture. This micro-organism appeared to be non-pathogenic to cattle, as well as to small laboratory animals, however, and inoculations of the cerebro-spinal fluid and of blood failed to set up disease. The results of cultural examinations and inoculations encouraged the suspicion that the disease is probably not associated directly with infection with a micro-organism.

Swine fever.—In further work on the survival of the virus in salted carcases, it was shown that " smoking," as usually carried out, cannot be relied upon to destroy the virus.

Verminous gastritis.—Field experiments have been carried out to investigate the immunity developed by lambs towards verminous gastritis, and have given results which show that an immunity is acquired as a result of early infection, and may be strong enough to enable lambs thus protected to exist on a heavily infected pasture where others, not so protected, die. Lambs placed on infected pasture soon after birth survived throughout the summer, but others which were sheltered from infection in early life quickly began to show symptoms of verminous gastritis when placed on the infected pasture, and died.

Further observations were also made on the differential immunity shown by individual lambs to the various species of parasitic worms causing verminous gastritis. Counts of the numbers of the various species have shown some remarkable differences in the extent of infection, and it was found that immune animals may carry a large number of the third stage larvæ of some worms (*Nematodirus* having been particularly noticed) but few of the adults, suggesting that the immunity inhibits the development of the young worms but does not kill them immediately.

Syngamiasis.—Waite's experiments on the association between earth-worms and *Syngamus trachea* have been repeated, and it has been shown that earthworms can act as true intermediate hosts ;

and that syngamus larvæ can live in them as true parasites and are not merely carried in a mechanical way, as had been generally supposed after it had been established that infection can be brought about by direct feeding of the infective larvæ. Infection appears to remain alive in the earthworms for a much longer period than it does in the soil.

Verminous bronchitis in adult cattle.—An opportunity was afforded for the investigation of an unusual outbreak of acute verminous bronchitis in which three of five cows died, but calves grazing in the same pasture remained healthy.

The observations lead to the conclusion that massive infestation with the larvæ of *Dictyocaulus viviparus* may speedily break down the resistance of adult cattle : that the amount of infective material on the grass may at times be so great as to bring adult cattle to the point of death within as short a time as 11 days : that the distribution of infective larvæ on a pasture may be very unequal : and that in the absence of reinfestation the worms carried by heavily infected adult cattle are speedily eliminated.

The association between parasitic worms and bacteria.—Experiments have been carried out to ascertain whether parasitic worms are of any importance in assisting pathogenic bacteria to invade the animal body. *Bacillus suipestifer* has been used as the test organism, and equal doses have been given to parasite-free rabbits and to rabbits heavily parasitised by *Graphidum strigosum* (a comparatively large stomach worm which injures the mucous membranes). Results obtained up to the present time do not indicate that parasitic worms are of any importance in this particular respect ; further work is being carried out, however, using another species of worm which is parasitic in the small intestine.

Fowl paralysis.—Investigations have been continued on a small scale, but no significant results have been obtained.

Fowl pox.—The pigeon-pox vaccine has again been employed on a very large scale, and during the year 613,483 doses were prepared and issued for use in the field. The general results were again excellent, and the reported failures were very few indeed, but these few appeared to be definite and to call for further investigation.

Pheasant pox.—An outbreak of disease in young pheasants, associated with heavy loss, was diagnosed as pheasant pox. The disease was transmitted by inoculation to pheasants and also to fowls, and the virus was shown to be closely related immunologically to the viruses of fowl pox and pigeon pox.

Fowl typhoid.—During the year 8,459 doses of vaccine were prepared and issued for use in infected flocks. As in previous years, the results were reported to be highly satisfactory.

Salmonella infections in ducks.—Salmonella infections have been shown to be responsible for a number of epizootics in ducklings,

involving a high mortality. One outbreak of this kind was associated with the presence of *B. enteriditis*, and in several outbreaks *B. aertrycke* has been found. A number of adult ducks were shown to be chronic " carriers " of infection, and in some cases the organism was isolated from the diseased ovary, but bacteriological examination of 100 eggs from " carrier " ducks gave negative results (2).

Further investigations are being pursued.

Miscellaneous investigations have included several enquiries into outbreaks of pneumonia in cattle. In such cases a *Pasteurella* is usually present in large numbers, but its real importance (if any) in relation to the ætiology of the disease has not yet been satisfactorily determined.

It has been shown that chloral hydrate may be employed as an anæsthetic for poultry. The depth of anæsthesia is very satisfactory, and the method appears to be free from serious risk.

Titles of papers issued during the year.

1. Andrews, W. H.: Vaccination against bovine contagious abortion, and the relation of this disease to undulant fever of man. *50th Ann. Cong. Nat. Vet. Med. Assoc.*, August, 1932. Also, *Vet. Rec.*, October 8th, 1932.
2. Hole, N.: Salmonella infections in ducklings. *J. Comp. Path. and Thera.* **45**, 161–171, 1932.
3. Taylor, E. L.: Some significant points concerning the parasitic worms of fowls and the causation of worm disease. *Vet. J.*, **87**, 1, 28–32, 1931.
4. ————: Notes on Ascaris and lungworms in pigs. *Ibid.*, **88**, 10, 438–441, 1931.

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27. ANIMAL DISEASES RESEARCH ASSOCIATION, EDINBURGH.

Tick-borne fever (3, 6).

Ætiology.—A large number of blood films from cases of tick-borne fever have been examined, and it has been found that cytoplasmic inclusions are constantly present in the leucocytes of the blood of affected sheep. These inclusions vary in size and form, and occur principally in the polymorphonuclear cells, but are also found in transitional and eosinophile cells.

A large number of films have been prepared from the blood of normal sheep, and from sheep suffering from diseases other than tick-borne fever. In none of the control cases have these inclusion bodies been found.

The inclusion bodies appear in the blood upon the onset of the febrile attack, and they gradually diminish in number as recovery progresses.

Filtrates prepared from infective blood have consistently failed to infect susceptible sheep. The possible pathogenic significance of the cytoplasmic inclusions has yet to be determined.

It has been found that the infective agent survives in the tick for at least 14 months after the tick moults ; that ticks are infective as early as 15 to 19 days after moulting. Infective ticks which complete their engorgement on sheep before these develop the febrile reaction were found to be still capable of causing infection in the next stage of their development. Evidence that infection cannot pass through the egg of the tick is accumulating.

Louping-ill (1, 2, 3, 4, 7, 8).

Pathogenesis.—An investigation into the spread and distribution of the virus in the body of the sheep in relation to the pathogenesis of the disease has been undertaken.

The investigation is not yet complete, but the evidence suggests that multiplication of the virus occurs primarily in the spleen and blood, and that invasion of the central nervous system commences at about the third day.

It has been found that louping-ill virus survives in the tick for at least 14 months after the tick moults. There is evidence to suggest that an infective tick cleanses itself of virus by engorging upon a non-susceptible host.

Further evidence has been obtained in support of the hypothesis that the occurrence of tick-borne fever predisposes to the invasion of the central nervous system by louping-ill virus.

Vaccination.—As previously reported, the protective powers of a formalinised vaccine have been tested during the recent louping-ill season. The results have been very encouraging, and it is proposed to repeat the test on a larger number of animals next spring.

Braxy.—Field experience with vaccines prepared from formalinised whole culture suggests that this method of immunisation represents an effective means of controlling the disease. In a controlled field experiment in which 2,470 hoggs were inoculated, and 1,693 hoggs on the same hirsels were left as controls. the braxy mortality in the inoculated group was 0.64 per cent., as compared with 6.73 per cent. in the control groups.

Contagious bovine abortion.—A commencement has been made with a scheme of research which has as its object the study of immunogenic methods in this disease.

Enzootic abortion in ewes.—The results of two field experiments showed that the feeding of phosphates in the form of wheat bran and bone meal, while raising the phosphate content in cases of aphosphorosis, had no appreciable influence in reducing the abortion rate. The investigation is being continued.

Lactation tetany in cows.—In a biochemical examination of 31 cases, the magnesium values were found to be consistently low. The investigation is proceeding.

Scrapie.—The manner by which scrapie infection is contracted and communicated to susceptible sheep is obscure, but systematic

enquiry over the last two years suggests that the contagion may be mediate through the medium of the grazings. In order to test this view, an experiment has been initiated on the Moredun pastures.

Further evidence has been obtained that the thyroid and adrenal glands are consistently enlarged in scrapie, but the significance of these changes cannot be determined until further disease controls have been examined.

Since there is reason to believe that the metabolic rate in scrapie is abnormally high, an investigation is being undertaken with the object of determining the standard metabolism of scrapie sheep as compared with normals.

Grass sickness.—A systematic chemical examination was made of 105 specimens of blood from cases of grass sickness and control animals. The results have now been tabulated and submitted to statistical examination.

Twenty-one collections of sweepings from infected pastures were made. The material was administered to horses by nasal insufflation, and by feeding.

The washings from soil and turf from infected pastures were administered by stomach tube.

In all cases the results were completely negative.

Attempts to reproduce the disease by vagotomy in test horses were also negative.

Milk fever.—Evidence has now been obtained that the injection of assimilable salts of calcium immediately after calving, and repeated after an interval of twenty hours, will effectively prevent the occurrence of milk fever in cows.

Titles of papers issued during the year.

1. Brownlee, A., and Wilson, D. R.: Histopathology of louping-ill. *J. Comp. Path. and Therap.*, **45**, 67, 1932.
2. Gordon, W. S., Brownlee, A., Wilson, D. R., and Macleod, J.: Studies in louping-ill.—1. Sections A and B. *Ibid.*, **45**, 106, 1932.
3. ————: Tick-borne fever (a hitherto undescribed disease of sheep). *Ibid.*, **45** (4), 301–312, 1932.
4. Greig, J. R.: louping-ill. *Trans. H. and A. Soc.*, June, 1932.
5. ———— and Dryerre, H.: Prophylaxie de la Fievre Vitulaire. *Réc. de Méd. Vét.*, **107**, 404, 1932.
6. Macleod, J.: Preliminary Studies in the tick transmission of louping-ill. *Vet. J.*, **88**, 276, 1932.
7. ————: The Bionomics of *Ixodes ricinus* L., the " sheep tick " of Scotland. *Parisit.*, **24**, 382, 1932.
8. ———— and Gordon, W. S.: Studies in louping-ill.—II. Transmission by the sheep tick, *Ixodes racinus* L. *J. Comp. Path. and Therap.*, **45**, 240, 1932.

28. ANIMAL DISEASES DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Abortion.—In the report for the academic year 1930-31 reference was made to investigations being carried out on a dairy herd affected with contagious abortion. These investigations indicate the difficulty of building up a " clean " herd on the basis of the agglutination test. Milk samples from individual cows in this herd have been examined to determine the percentage of cows excreting *Br. abortus* in their milk. A short paper on this subject was read before the Royal Institute of Public Health, Belfast Congress, May 12th, 1932 (1). A simple method of obtaining original cultures from aborted fœtuses is given in the paper.

Fowl paralysis.—A paper referring to this subject (2) was read before the Harper Adams Poultry Conference. Successful transmission results have been obtained in a few cases. This disease under certain circumstances appears to be highly infectious. Other experiments in progress have been nullified owing to the appearance of the disease in the control groups. Fowl reared from eggs from affected stock have developed the disease.

Bacillary white diarrhœa.—The blood testing scheme for the eradication of the disease mentioned in the previous report is expanding at a rapid rate. A questionnaire dealing with the scheme was sent to the various poultry farms. The answers have been analysed and are embraced in the paper (2) referred to under fowl paralysis. These show an overwhelming majority of poultry keepers in favour of the scheme.

Tuberculosis.—Experiments with M. Spahlinger's anti-tuberculosis vaccine are being carried out. An interim report has been published (3). Results to date show that five out of seven control animals died after administration of the test virus in approximately one to two months, while all eleven animals vaccinated with the preparation termed " new " vaccine by M. Spahlinger are alive and clinically healthy. After slaughter of the various animals a final report giving conclusions, etc., will be published.

Titles of papers issued during the year.

1. Lamont, H. G.: Infectious abortion in cattle. *Vet. Rec.* August 20th, 1932.
2. Kerr, W. R.: Poultry diseases experimental work. *Harper Adams Utility Poult. J.*, **17**, 11.
3. Lamont, H. G., Kerr, W. R., and Shanks, P. L.: Report on experiments with Spahlinger's Anti-tuberculosis Vaccine. *Vet. Rec.*, December 17th, 1932.

G.

ANIMAL NUTRITION
and
ANIMAL BREEDING.

29. ANIMAL NUTRITION RESEARCH INSTITUTE, CAMBRIDGE UNIVERSITY.

Grasses.—During the past year Mr. F. W. Foreman has continued his investigations of the changes occurring during growth in pure cultures of grasses and wild white clover. In addition to work on the constitution of special substances isolated new enquiries have been instituted with a view to clearing up certain points so as to make the final account of the investigation as complete as possible, *e.g.*:

The distribution in the plant of various substances embraced in the investigations. Comparisons of (*a*) stem and leaf, (*b*) live leaves with leaves which died naturally on the plant and which under certain circumstances form part of the produce, (*c*) material exhausted by the time seed had ripened, before and after exposure to rain, with material of high quality, in attempting to ascertain what materials in roughage are of least use to the animal.

The distribution of various constituents including nitrogen, phosphorus and mineral matter in the fractions obtained in a particular scheme of fractionation which has proved of great service in the investigations.

The intensification of the effects of ammonium sulphate upon the changes brought about by applying very heavy successive top dressings.

Comparison of the results of applying the new schemes of investigation to perennial rye grass with the results similarly obtained in the case of the fæces derived from feeding the rye grass alone to sheep.

Fæces of cattle and sheep fed on grass alone examined for evidence of putrefaction in the intestine and its extent.

The studies of the effects of enzymes has been continued.

The data accumulated are now very extensive. Much progress has been made in their closer study for publication purposes.

Other work dealing with the constitution of proteins of agricultural importance, including those in the vegetative parts of plants, has also received continuous attention.

Pastures.—Dr. H. E. Woodman and his co-workers have brought to a conclusion the main phase of their pasture investigations, namely, the study of the influence of the intensity of grazing on the yield, composition and nutritive value of pastures. The subject has now been investigated under conditions varying from those of non-rotational close-grazing to those of 5-weekly rotational close-grazing. An account of the final stages of this branch of the grassland work (24) and a brief article, summarising the main practical and scientific aspects of this series of investigations, have been published (3).

The work on the influence of intensive fertilising on the yield and composition of good permanent pasture has now been in progress

for four seasons and will be continued for at least another year. The initial publication by Dr. Woodman and Dr. E. J. Underwood, embracing the results obtained in the first two seasons of this investigation, has already appeared (2).

The first half of an investigation into the value of pasturage for winter grazing was carried out during the winter 1931-32 by Dr. Woodman and Mr. Oosthuizen (a Ph.D. student from Pretoria University). It is hoped, if weather is favourable, to complete this work during the coming winter, 1932–33.

With the collaboration of Dr. R. E. Evans and Dr. D. B. Norman, Dr. Woodman has commenced a series of investigations into the nutritional characteristics of the lucerne crop, and very striking results have already been obtained.

Dr. Woodman and Dr. J. Stewart have carried a stage further their investigations into the mechanism of cellulose digestion in the ruminant organism, and during the past year have published a further paper dealing with the action of cellulose-splitting bacteria on the fibre of certain typical feeding stuffs (5).

The pig-feeding investigations have been continued, and in collaboration with Dr. R. E. Evans and Mr. A. W. Menzies Kitchin, Dr. Woodman has studied the question of the utilisation of oats in the nutrition of swine. An account of this work has been published ; this should help to overcome the prejudice which exists in this country against the inclusion of oats in the rations of pigs (6). Dr. Woodman and Dr. Evans have also published an account of their work on the value of degermed cooked maize meal in the feeding of pigs (7).

The final account of the two years' work carried out by the Animal Nutrition Institute, in conjunction with the Animal Husbandry Section, on the relative values of oats, molassed beet pulp and dried sugar beet pulp for fattening of store cattle has now been published by Dr. Woodman, Mr. Mansfield and Mr. Garner (1).

Dr. R. E. Evans has now published his work on the cystine content of pasture grass, and arising from this work, Dr. Woodman and Dr. Evans have commenced an investigation into the utilisation of various forms of sulphur compound by bacteria, in the hope of throwing light on the utilisation and metabolism of sulphur in ruminant animals, a problem of importance in connection with the nutrition of the wool-producing sheep (10).

Calorimetry.—Work on the metabolism of various breeds of English pig by Dr. T. Deighton has continued along previous lines. Owing to various difficulties it was found impossible to keep the animal house heated during the winter and this appears to have had a very marked effect upon the animals which in other respects have received the same treatment and rations as in previous years. It is hoped that the continuation of the work will afford definite and useful data, among other things, on this debated and important matter of keeping pigs warm.

The construction of the balanced calorimeter for poultry nutrition work has been subject to some delay as it has been found impracticable to do without insulation entirely, as had been hoped. There appears to be good reason to hope, however, that this may not mean the abandonment of the idea of a transparent instrument in which the experimental animals can be under constant observation. Preliminary tests of a double celluloid insulation have given satisfactory results and the conversion of the apparatus on these lines is in progress.

A paper embodying the results of the work of the department on surface area of animals has been published (12).

The mineral and vitamin requirements of growing swine (calcium, phosphorus and vitamin D).—Mr. George Dunlop, Ministry of Agriculture Scholar, has been engaged in an investigation on this subject Young pigs of 25–60 lb. fed a basal ration consisting of barley meal 35 parts, white sharps 30 parts, crushed oats 20 parts, linseed cake meal 12 parts, meat and bone meal 3 parts, (supplying 7 gms CaO to animals of 120 lb. live weight), showed a sharp fall in blood calcium after 10 weeks on the ration and later some of them developed nutritional anæmia. After losing appetite, they fell off in live weight increase till growth ceased and rickets developed, which condition was cured by the addition of ½ per cent. of limestone and 10 cc of cod liver oil to the daily ration.

It was shown that addition of cod liver oil to the ration at the rate of 5 cc per day gives normal growth with only slightly subnormal blood calcium and freedom from rickets and anæmia. Further addition of cod-liver oil (20 cc. per day) merely gave similar results.

Addition of ½ per cent limestone to the ration which increased the amount consumed daily by a 120 lb. pig from 7 gms CaO to 12 gms, gave normal growth in pigs which had also a normal blood picture. Addition of cod-liver oil in doses of 5 cc. and 20 cc. merely served to give a higher blood Ca.

Mr. Menzies Kitchin has further investigated the effects of substitution of wheat for barley in the rations fed to young pigs during growth. It was found that wheat meal (60 per cent.) satisfactorily took the place of barley (63 per cent.), thus confirming the work referred to above.

Poultry nutrition.—Studies on the physiology of fat formation in the bird have continued. After a preliminary analysis of fat taken from various areas of the body had shown that, as indicated by the iodine values, there were no significant differences in composition, Dr. E. M. Cruickshank has investigated the effect of food fat on the composition of body fat and yolk fat. Hemp seed fat, mutton fat and palm kernel oil were used as food fats. With regard to the body fat, both mutton fat feeding and palm kernel oil feeding resulted in the lowering of the iodine value of the

body fat, whereas hemp seed feeding resulted in a raising of the iodine value. With regard to the fatty acids of the egg yolk, hemp seed feeding definitely raised the iodine value from 85–90 to 123–126, the maximum values being reached after 16 days' feeding. In the case of both mutton fat feeding and palm kernel oil feeding, no marked effect on the normal values of the fatty acids of the egg was noted.

An investigation on the possibility of the use of palm oil as a substitute for mutton fat in fattening table poultry has been carried out as the result of a request from the Imperial Institute, and the results, which were favourable, are reported in the Imperial Institute Journal.

A preliminary investigation into the causes of " watery white " has been undertaken, and the types of " watery white " in eggs defined. It is hoped to pursue this investigation further in co-operation with the Low Temperature Research Station at Cambridge.

Genetics.—Mr. M. S. Pease is continuing his experiments on the commercialisation of the sex-linked Cambar breed of fowls, and has made good progress.

Reproduction and growth.—Continuous and steady advance has been made in the study of these subjects. The general object of the work is, first, to obtain a greater knowledge of the processes of reproduction and growth, and secondly to show how to apply this knowledge practically to the economic advantage of the practical breeder.

During the past year a third and enlarged edition of the Ministry's Research Monograph by Dr. Marshall and Mr. J. Hammond has been published in the form of a bulletin under the title " Fertility and Animal Breeding " (16).

At the Centenary Meeting of the British Medical Association Dr. Marshall opened a discussion on the sex hormones and their cyclical production in animals, and a number of physiologists and biochemists from different countries took part (14).

Among the more striking results of investigations undertaken at the Institute are those of Professor T. H. Bissonnette (Trinity College, Hartford, Connecticut, U.S.A., National Research Fellow), who came to work with Dr. Marshall. Professor Bissonnette showed that ferrets during the non-breeding season could be brought into full breeding activity by subjecting them daily during part of the evening to strong electric light, thus imitating in this respect the conditions existing during spring and summer when there is more prolonged daylight. The results were communicated to and published by the Royal Society (17). A further paper on reproduction in the ferret by Dr. Marshall is now in the press.

Dr. Marshall has also begun an investigation on the effects of additional light rations to sheep, and under the guidance of Mr.

Hammond experiments are being arranged in certain parts of the country on the results of extra light on the sexual processes in cows.

During the year the location of the experiments on breeding has been transferred from the buildings at the Field Laboratories, Milton Road (which have been handed over to the Veterinary Department) to the new buildings on the University Farm which were erected by a grant obtained from the Empire Marketing Board.

Mr. Hammond's work on reproduction in the mare has consisted of a study of changes occurring during pregnancy. It was found that changes in the mucous membrane of the upper vagina and cervix were such that a diagnosis of pregnancy could be made by means of a simple manual exploration without the necessity for biological tests and laboratory equipment.

The inbred stock of rabbits has been maintained for a study of problems in fertility and growth. The work on foetal degeneration reported last year has been continued. Most of the colony has been employed in studying the changes occuring during pregnancy, particularly with regard to the duration of pregnancy, the growth and development of the young during uterine life, and the factors affecting the size and viability of the young at birth.

Mr. Hammond has also commenced experiments with sheep to find out exactly the times of year during which sheep will breed, and if possible to find means of extending this and so spreading the time of lambing throughout the year. This work is correlated with that referred to above on the effects of varying light rations.

Measurements of bacon at the Dairy Show and of carcases of cattle, sheep and pigs at the Smithfield Show have been continued. In conjunction with Mr. G. N. Murray of the Department of Agriculture, Union of South Africa, Mr. Hammond has worked out some of these results, which have already been used in fixing Show standards for judging purposes.

The results of Mr. Hammond's work on " Growth and the development of mutton qualities in the sheep," which have extended over a number of years, have now been published (21). Mr. Hammond's " Report on Cattle-breeding in Jamaica and Trinidad " has also been published by the Empire Marketing Board (20).

During the summer, at the invitation of the Animal Husbandry and Veterinary Divisions of the Iowa State College at Ames, Iowa, U.S.A., Mr. Hammond gave courses of lectures on the physiology of reproduction, milk secretion, growth and meat production. He also took the opportunity of visiting the Departments of Animal Husbandry and Dairying at Washington and many Experiment Stations in the Eastern and Middle Western States, as well as seeing something of the practical conditions of animal production and marketing in these areas. At the end of the course of lectures Mr. Hammond received the honorary degree of D.Sc. from the University of Iowa.

Dr. Walton has proceeded with his work on the survival of

spermatozoa *in vitro*. The experiments on the survival of fertilising capacity in gas mixtures with various pressures of oxygen and carbon dioxide are still in progress. Data are yet incomplete, but it would appear that an oxygen pressure of less than 15 mm. Hg. is the most favourable. Pressures greater than this are definitely inimical. The pressure of carbon dioxide required lies between 30 and 80 mm. Hg. and the effect is probably due to the maintenance of the pH of the medium. Under the most favourable condition fertilising capacity has been maintained for 7 days at + 3°C.

In Dr. Walton's investigations on the ascent of spermatozoa in the female tract (in collaboration with Professor Florey and Miss E. O. Whetham) permanent uterine fistulæ were established in rats, rabbits and guinea pigs. After recovery it was possible to remove samples of the uterine contents for examination at short intervals after coitus. In the rabbit spermatozoa enter the uterus by means of their own motility. In the rats and guinea pig, contraction of the vagina is effective in forcing seminal fluid through the cervix to the upper end of the uterus. These results are comparable with observations on domesticated animals. A preliminary account has been communicated to the Physiological Society.

In a joint investigation between Dr. Walton and Miss E. O. Whetham a series of experiments on the survival of the spermatozoa in the fowl has been completed. The discovery of Professor Ivanoff that fertility continues after irrigation of the peritoneal cavity and oviduct with a spermicide has been confirmed, but it is pointed out that although the results are consistent with the theory that the spermatozoa penetrate the immature ova, additional evidence is required before the theory can be definitely accepted as proved.

In a joint research between Dr. Walton and Mr. Pease, further data on the inheritance of a peculiar nervous abnormality in calves have been obtained from Mr. Burman, of Wappenham. The abnormality appears to be due to a dominant mutation with variable intensity of expression. It has been followed in three generations. The abnormal specimens have been handed over to the Institute of Animal Pathology for investigation.

Dr. Walton has also been engaged in work with Dr. Marshall on the factors controlling the breeding cycle and plumage changes in ducks and on the effects of castration. The positive effects of extra lighting found in other animals, as referred to above, have been extended to these birds.

Breeding of dairy cattle.—Investigations on the importance of the progeny test and the proved sire in constructive dairy cattle breeding have been made by Mr. J. Edwards. Methods used in selecting dairy bulls, including the Breeding Index System, were examined. Results have been published (22).

Bull-Recording. As an outcome of the research noted above a practical scheme for regular progeny-recording within a Milk

Recording Society was drawn up and circularised. It has been adopted by some Societies and adapted by others.

Milk-Production in the Tropics.—A detailed study of data collected by Dr. J. Hammond during his visit to the West Indies, was undertaken by Mr. J. Edwards with a view to discovering the optimum mixture of European and Zebu bloods required for milk-production in the Tropics (23).

Wastage of dairy cows.—The collection of data for this enquiry ceased on October 1st, 1931. Since then the collation of the returns has been completed and a Report has been sent to the Ministry of Agriculture (March, 1933) by Dr. Sanders.

In general it may be said that the results for the several years agreed very well. Unfortunately it was found to be impossible to obtain records of all the cows leaving the herds, 20 per cent. being missed; from supplementary enquiries it appeared that the distribution of the missed cows over the various causes of removal was the same as that of those for which records were received. It is believed that the relative importance of the causes of removal has been accurately determined, but the estimate of the herd life ($3\frac{1}{2}$ years) cannot be regarded as very precise.

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4. ————: Bone charcoal as a source of minerals for farm animals. *J. Min. Agric.*, **39**, 403, 1932.
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15. ————: Light as a factor in sexual periodicity. *Nature*, **129**, March, 1932.
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18. Hammond, J.: Recent advances in agricultural physiology. *Sci. Prog.*, **37**, 106, 1932.
19. ————: Le développement de la sécrétion lactée. Jubilée en l'honneur du Prof. C. Porcher, Chamberg, 1932.
20. ————: Report on cattle-breeding in Jamaica and Trinidad. Empire Marketing Board.
21. ————: Growth and the development of mutton qualities in the sheep. Oliver and Boyd, Edinburgh, 1932.
22. Edwards, J.: The progeny test as a method of evaluating the dairy sire. *J. Agric. Sci.*, October, 1932.
23. ————: Breeding for milk-production in the Tropics. *J. Dairy Res.*, **3**, 2, 1932.
24. Woodman, H. E., and Norman, D. B.: Nutritive value of pasture—IX. The influence of the intensity of grazing on the yield, composition and nutritive value of pasture herbage. *J. Agric. Sci.*, **22**, 4, 852–873, October, 1932.

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30. ROWETT RESEARCH INSTITUTE, ABERDEEN.

Research on fundamental problems of nutrition is carried out in the Institute itself, and practical experimental work with groups of farm animals on the Duthie Farm attached to the Institute.

ROWETT INSTITUTE.

Influence of nutrition on susceptibility to disease.—Studies on the influence of nutrition on susceptibility to disease which have been proceeding for the last few years are being continued. In earlier work it has been established that certain deficiencies in the diet are reflected in abnormalities in the composition of the blood as determined by chemical analysis. In experiments with sheep it has been found that changes in the level of calcium in the blood serum and inorganic phosphorus in the blood can be correlated with the composition of the diet and also with clinical symptoms. The last two years' data afford some evidence that these changes due to the diet are also correlated under natural conditions with the death rate and the birth rate. During the past year it has been shown that phosphatase, an enzyme concerned with the metabolism of calcium and phosphorus, is also affected by the diet, and the changes of the amount of the enzyme present in the blood seem to precede the changes in the calcium and phosphorus levels and to occur before clinical symptoms are evident. The phosphatase level would,

therefore, appear to be of considerable prognostic value, as changes in the amount of phosphatase occur before any other known signs of malnutrition.

Chemical and serological examinations of the blood of the same nature as those being done on sheep have been carried out during the past year on a group of cows through the complete physiological cycle of reproduction and lactation. The results obtained show that in these animals there is a decrease in serum calcium following parturition. The marked decrease found in milk fever and believed to be the cause of the symptoms of that disease would appear to be merely an exaggeration of this normal change in the level of serum calcium at this period. The main object of this work was to obtain reliable data on the limits of variation in the calcium and inorganic phosphorus of the blood of cows, prior to an investigation to ascertain whether these are affected by the diet in the same way as in the case of sheep, and if so whether they can be correlated with susceptibilty to some of the commoner diseases in dairy cattle.

Intestinal absorption.—The study of the factors affecting the absorption of nutrients from the intestine has been continued. Recent data seem to show that there is a definite relationship between rate of absorption of sugar and of the concentration of sugar in the blood, and that the latter can be used as an indication of the rate of absorption of carbohydrate from the intestine.

X-ray observations are being made on the rate of passage of food along the alimentary canal in the ruminant, and also in the fowl. These are throwing further light on the processes of digestion. One of the interesting facts brought to light is that excitement even from apparently trivial causes induces inhibition of intestinal movements.

Minerals required in traces.—Feeding experiments on rats with fluorine confirmed previous work with regard to the influence of fluorine on the growth of the teeth. In further tests, in which the amount of fluorine fed was not sufficient to cause observable harmful effects on the first generation, it was found that the young of the second generation did not thrive. Some of the limestones used to balance up mineral deficient rations are rich in fluorine, and these tests are being done to ascertain the nature of the harmful effects of excess of fluorine and the amount which may be present in the ration without causing harmful effects.

During the past year joint work is being done with the Macaulay Soil Institute to ascertain the influence of the amount of lime in the soil on the iodine content of the vegetation. The results already obtained seem to indicate that the addition of lime to the soil is followed by a reduction in the iodine content of the pastures. Endemic goitre and other effects of iodine deficiency are frequently found in limestone areas, and have been attributed to excess of limes. It seems probable that the influence of the lime is indirect and due to lowering of the iodine content in the vegetation. Other

work on iodine has meantime been suspended pending the outcome of an investigation to establish a more reliable method of analysis for the minute quantities present in biological material.

Physiology of the fowl.—Experiments are being carried out to show the effect of vitamin D on the mineral metabolism of cocks and pullets. Blood analyses have shown that large doses of the vitamin affect the serum calcium and the phosphatase of the plasma. The latter appears to be high in birds laying a large number of soft shelled eggs, and in those birds which are not laying due to a deficiency of vitamin D or minerals. Ill effects of over-dosage of vitamin D appear to be different in the two sexes, owing possibly to the fact that when a hen is laying the serum calcium will ordinarily rise to two or three times the normal non-laying level.

In continuation of the work on the carbohydrate metabolism of the fowl, it has been shown that the absorption and utilisation of the simple sugars in the chicken differs somewhat from that found in the rat. The absorption of glucose is very rapid, and, unlike that in the rat, does not remain constant while there is still sugar to be absorbed. The results of some studies on digestion and absorption have been published. Work on the respiratory metabolism of the fowl is also in progress, with a view to elucidating further some questions regarding the utilisation of carbohydrates.

Vitamin content of fish oils.—A series of chemical and biological tests are being made to determine the amounts of vitamin A and vitamin D in various kinds of fish oils. In a series of experiments begun last year it was found that the vitamin A content of halibut oil was over fifty times as great as that of cod liver oil.

Human dietetics.—Work in conjunction with the Hannah Institute is being done to ascertain whether dried separated milk can be fortified with vitamins and with iron so that comparatively small amounts of it would make good the deficiencies known to exist commonly in the carbohydrate-rich diet of children.

Duthie Experimental Stock Farm.

The most interesting results obtained in the experimental work during the past year have been as follows.

During the past year observations have been made on the influence of diet on susceptibility to disease in sheep. Lambs were taken from ewes at lambing and reared under artificial conditions free from the possibility of infection by parasites. Two groups were fed differently—one on an optimum ration and another on a poor ration. When half grown the animals were put to graze on heavily infested pastures. After three months grazing the animals were killed and the number of parasites in the stomach determined by post-mortem examinations. The results showed that the state

of nutrition of the animal as determined by feeding is an important factor in infestation. The animals on the poor ration had three times as many parasites as those which were well fed.

In another experiment it was found that under a system of rotational grazing of ewes and lambs in which the animals were moved into a new division of the field every ten days, infestation was markedly reduced compared with similar animals grazing continuously on the other part of the field, the degree of infestation in the lambs in the former case being only one-tenth. Investigations on the influence of feeding and management on infestation by parasites in sheep are being continued. This subject is of considerable economic importance as intestinal parasites are believed to cause more losses in sheep on arable land than any other disease. This work is being done in conjunction with the North of Scotland College of Agriculture and the Zoology Department of Aberdeen University.

Poultry.—Investigations have been made upon the rate of growth, egg production and economic return from chickens hatched at various dates. Early hatched chickens grew faster and laid earlier than those later hatched. In studies on the value of mineral supplements it has been found that under ordinary conditions when the birds have a run on pasture, provided lime is supplied *ad libitum*, in the form of oystershell or limestone grit, salt is the only mineral supplement which is of value for growth or egg production. In tests to ascertain whether the influence of the salt was due to sodium or chloride, results have been obtained which suggest that the important factor is sodium.

Beef cattle.—The calves on the experiment on rearing with different amounts of milk, referred to in last year's report, have come to maturity and been slaughtered. Those receiving a minimum quantity of milk, i.e. about thirty gallons supplemented with a well balanced meal ration complete in proteins, minerals and vitamins, have done as well as those receiving a hundred gallons. This confirms and extends earlier work done in conjunction with the East of Scotland College of Agriculture.

Subsidiary researches.—A number of tests have been carried out on pigs to ascertain the conditions under which the feeding of cod liver oil yields beneficial results to compensate for the cost. The results which are of immediate interest to pig feeders have been published (14).

Tests to ascertain whether tung-oil meal could be used as a feeding stuff for pigs have proved negative.

A quantity of silage was made last autumn according to the A.I.V. method which originated recently in Finland. The material appears to be satisfactory, and feeding tests are now being done with dairy cows to compare its value with that of ordinary silage.

Garrochoran Sheep Station.

At Garrochoran, a farm in a notably unhealthy district of Argyllshire, feeding experiments are being carried out to test the effect of nutrition on the incidence of disease in sheep under natural conditions. This is in continuation of work previously reported and the results have been published. Quantitative deficiencies in the pasture are being made good by feeding supplementary maize during the winter and early spring, and qualitative deficiencies by feeding a mineral and vitamin supplement.

Results in 1932 have confirmed those of the previous year. The supplementary feeding has been found to decrease the death rate amongst ewes and to increase the number of lambs surviving at sale-time. In addition, the feeding of maize has increased the total weight of fleece.

A further experiment has been carried out with groups of sheep, differently fed, to test the effect of nutrition on susceptibility to a bacterial toxin. The results of this test are already published. Briefly they indicate that sheep on poor natural pasture, with a complete supplement of maize and a mineral-protein-vitamin mixture, resisted the toxin better than sheep on poor pasture alone, while other groups, receiving modified supplements, were intermediate. The calcium and phosphorus content of the blood of sheep on pasture alone or on pasture plus maize was low, but normal values were obtained in the group receiving the complete supplement.

A study is in progress on the phosphatase content of the blood of sheep and it has been found that blood with a low calcium and phosphorus content has a high phosphatase value. Phosphatase content of the blood may therefore be found to be a more sensitive indicator of mineral deficiency of grazing animals than any hitherto available.

Joint experiments with the Woollen Research Industries Institute are being carried out to test the effect of nutrition on quality of wool and it has been found that the quantity of protein fed has little effect on the fleece. An improved technique has been evolved for wool sampling. The cystine requirements of the sheep are under investigation. The large amount of cystine present in wool cannot be accounted for by the amount present in pasture and foodstuffs, and it is suggested that the sheep is able to synthesise cystine. An experiment to determine the effect of carbohydrate deficiency on wool growth is at present in progress.

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31. (CHEMICAL AND) ANIMAL NUTRITION DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Poultry Nutrition.

Chicken rearing.—It was found that the addition of common salt to a cereal mash improved the growth and condition of chickens even when they received separated milk *ad lib.*, without any other liquid to drink. One quarter per cent. of common salt gave as good results as a supplement to a ration of cereals and soya bean meal as ½ per cent. or 1 per cent. salt. Further evidence was obtained that the sodium in common salt plays a bigger part than the chlorine when used as a supplement to ordinary rations. In a comparison of four groups receiving (*a*) an unsupplemented ration; (*b*) common salt; (*c*) sodium carbonate (equivalent in sodium to (*b*)); and (*d*) glycine hydrochloride (equivalent in chlorine to (*b*)), the following were the average weights at 7 weeks, (*a*) 133.5 gm., (*b*) 429.4 gm., (*c*) 343.1 gm., (*d*) 132.6 gm. At 12 weeks of age the mortality figures were (*a*) 55 per cent., (*b*) 7 per cent., (*c*) 6 per cent. The mortality figure of 55 per cent. in the unsupplemented group confirms the results of two previous experiments. It was found that

a mash containing 30 per cent. soya bean meal gave better growth than one containing 18 per cent. soya bean meal. In another experiment mashes containing 8 per cent. meat meal and 13 per cent. soya bean meal were compared with mashes containing 63 per cent. meat meal and 99 per cent. soya bean meal. These birds were kept intensively. The birds on the higher protein planes (28 per cent. crude protein in ration) grew more rapidly than the others. No pathological effects of the high protein rations were observed.

Laying experiments.—It was found that with hens as with chicks, where oystershell grit was supplied *ad lib.*, no mineral supplement other than common salt was necessary. An addition of ½ per cent. of common salt to the mash gave as good results as were obtained with higher levels. Work in progress on the requirements of the laying hen for protein when a grass run is available indicate that under these conditions the protein level may be reduced much below the level commonly recommended without any adverse effect on production or the health of the bird, provided salt and lime are supplied. Comparatively good results have been obtained from mashes containing 50 per cent. boiled potatoes. Disappointing returns were obtained from the use of artificial lighting.

Mineral balance studies.—The work on the storage of calcium and phosphorus by pullets prior to and at the commencement of laying has been extended to a consideration of sodium and potassium storage. The earlier results have been published (1). It appears that phosphorus may be intimately concerned with the function of shell formation, although the shell contains only very small amounts of phosphorus. The experiments now under investigation show that part of the benefit of common salt for laying birds on cereal plus soya bean meal rations is due to the favourable influence of this ingredient on calcium absorption; it does not at present appear that the voiding of phosphorus concomitant with egg shell formation involves any heavy drain on the sodium reserves of the bird. All the experiments in this series suggest strongly that laying birds receiving adequately balanced cereal plus soya bean meal rations do not require any extra source of phosphorus.

Sheep.

Mineral supplements for hill sheep.—Experiments in which mineral cubes are being fed to breeding ewes are in progress at three centres. At each centre there are two groups, one of which receives mineral cubes, the other serving as a control. Details are being kept of lambing records, mortality, liveweight of lambs and the general health of the ewes. The results so far obtained indicate that the mineral fed ewes have more milk and the lambs from these ewes are sturdier. Liveweight figures for lambs were obtained at two centres last season. In one case there was no significant

difference between the control and mineral-fed groups, whilst at the other centre the lambs from the mineral-fed ewes were appreciably heavier.

Composition of Milk.

The statistical analysis of data collected at the Agricultural Research Institute for Northern Ireland is still in progress, and two papers (2, 3) have already been published. The first paper deals with the influence of the season of the year and climatic conditions on the yield and composition of the milk of a herd, and has already been referred to. The second paper reports a study of the errors involved in certain systems of milk recording and shows that, when the milk is weighed weekly, testing for butterfat must be undertaken monthly, if errors of more than 10 per cent. in the lactation yield of butterfat are to be avoided. A third paper, dealing with variations in the composition of milk from the legal point of view, is in course of preparation. Data on the natural acidity of milk are still being collected. An investigation of the variations in the freezing point of milk is being carried out. The influence of such factors as the stage of lactation, the season of the year and the degree of acidity on the freezing point is being studied. Milk recording data are being used to study the transmitting ability of dairy bulls.

Titles of papers issued during the year.

1. Common, R. H.: Mineral balance studies on poultry. *J. Agric. Sci.*, **22**, Part III, 1932.
2. Houston, J., and Hale, R. W.: The yield and composition of milk with special reference to the influence of climatic conditions and other factors. *J. Dairy Res.*, **3**, 2, 1932.
3. ————: The errors involved in certain methods of estimating the lactation yield of milk and butter-fat. *Ibid.*, **4**, 1, 1932.

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32. PIG HUSBANDRY EXPERIMENTAL STATIONS.

(A) Harper Adams Agricultural College.

Seven experiments were completed during the year. The subjects comprised kind and amount of supplementary protein supply, lime-requirements, feeding value of ground oats and of dried whey, and a comparison of flaked maize with raw maize meal.

Previous conclusions as to the optimum proportion of soya meal in pig rations were confirmed, but evidence was obtained that with separated milk in place of soya meal a rather higher level of protein supply may be justifiable, or that alternatively the soya-cereal rations are capable of improvement with respect to some factor other than protein.

Evidence was obtained that lime-requirements are adequately

covered by an addition of 2 per cent. of ground limestone to soya-cereal rations, but that 3 per cent. is definitely harmful.

Ground oats proved inferior to wheat sharps for pigs up to about 16 weeks old, but thereafter were of equal value, provided the oats did not form more than about 25 per cent. of the total ration.

Dried whey, used to the extent of 10 per cent. in replacement of maize meal, did not prove more than equal to the latter, except with respect to quality of carcass. The slight inferiority of the maize in the latter respect is explained by its higher oil-content.

Flaked maize proved to be more palatable to young pigs than raw maize meal, but at no stage of growth was any difference shown either in rate of liveweight gain or in efficiency of utilisation of food.

Titles of papers issued during the year.

1. Crowther, C. : The work of the Harper Adams Agricultural College Pig Feeding Experimental Station, 1926–31. *J. Roy. Agric. Soc.*, **92**, 1, 1932.
2. ———— : Influence of maize germ on bacon. *J. Min. Agric.*, **39**, 5, 1932.
3. Crowther, C., and Wright, T. S. : Minerals in relation to pig feeding. *Ibid.*, **39**, 3, 1932.
4. ———— : The work of the Harper Adams Agricultural College Pig Feeding Experimental Station in 1931. *Pig Breed. Ann.*, 1932–33.
5. Wright, T. S. : Dried sugar beet pulp for pigs. *J. Min. Agric.*, **39**, 2, 1932.

(B) South Eastern Agricultural College, Wye.

An experiment was carried out designed to ascertain whether the addition of dried separated milk to the supplementary ration fed to sucking pigs would be beneficial. No clearly marked difference was obtained. The results showed that, whilst the growth of a sucking pig was influenced by the quantity and nature of the supplementary ration, the quantity of supplementary food eaten was determined rather by their breeding and the milk supply of their dam than by the nature of the supplementary ration. The possibility of influencing the sow's milk supply by feeding was investigated and the results obtained from two rations, which differed widely in composition, were compared. No clearly defined result was obtained owing to the fact that one of the trial rations was eaten more readily by the young pigs than the other. An analysis of the results obtained in the sow-feeding trials carried out during the past three years has been made and indicates that the growth of sucking pigs is influenced to a marked degree by the feeding of the sow during the first month after farrowing.

Investigations as to the maximum economical proportion of sharps in the ration of growing and fattening pigs were carried out. It was shewn that pigs could be fattened on a ration containing 60 per cent. of sharps, but that when over 70 lb. live weight with pigs confined to styes more economical results were obtained with rations containing a smaller percentage.

Titles of papers issued during the year.

1. Fishwick, V. C.: Wheat meal v. Millers' offals. *J. Min. Agric.*, **38**, 8, 1931.
2. ————: Rearing sucking pigs. *Ibid.*, **38**, 9, 1931.
3. ————: Some cheap pig rations. *Farmer & Stockbreeder*, **46**, March, 1932.
4. ————: Rearing sucking pigs. *J. Min. Agric.* (in the press).

33. NATIONAL POULTRY INSTITUTE.

(A) National Institute of Poultry Husbandry, Harper-Adams Agricultural College.

Waterfowl and Turkey Production.

Fish meal v. meat and bone meal for egg production.—Further results of experiments commenced in 1929 confirm conclusions made in 1931, viz. that the meat and bone meal fed birds gave the greater profits over cost of food. Egg production was approximately equal, with slightly larger eggs in the fish meal pen.

Pellets v. mash for egg production.—Mash-fed ducklings gave slightly greater final weights than pellet-fed birds at an almost equal food cost and consumption (11).

Intensive rearing of turkeys.—Previous experience on the Institute farm with rearing under ordinary extensive conditions has been very unfavourable owing to heavy incidence of disease. Application of intensive methods to turkey rearing has proved more successful, leaving a margin of 15s. per poult over food costs (8).

Experiments at present in progress.—

(i) Comparison of soya bean meal v. fish meal for laying ducks.
(ii) The economic rearing of an early v. a late hatch of turkeys under intensive methods.
(iii) A preliminary experiment on the rate of growth, food consumption, and costs of Roman geese.

Conjoint work in progress.—

(i) The time a duck lays in relation to the place of the egg in the sequence.
(ii) The keeping quality of duck eggs.
(iii) Dead-in-shell and abnormalities in ducks.
(iv) The reason of non-hatching of double yolk eggs.

Production of Table Chickens.

Battery brooding v. floor brooding.—This experiment is regarded as being of great economic importance, but final conclusions can only be made after a number of years' research with very large numbers of birds. The weights obtained so far with the battery

brooding have been as heavy at 13½ weeks as on floor brooders, but the birds have not shown such good condition (9).

The following experiments have been carried out in the battery brooder :—

Protein supply experiment.—The standard mixed protein ration gave better results than dried milk alone (9).

Mineral supply experiment.—The addition of 5 per cent. ground limestone to the rations of chickens fed on cereals and milk retarded growth (9).

Bran experiment.—The substitution of bran for maize in the all-mash ration had no marked influence on the rate of growth or condition of the chicks.

Fattening experiments.—

(i) Chickens well-fed on range did not need the usual 18 days fattening in the crates.

(ii) Crammed birds were significantly heavier than trough-fed birds.

Contrary to general opinion range-fed birds consumed less food per lb. live weight increase than those fed in confinement.

Egg Quality Studies.

Owing to the lack of facilities this work has had to be carried out in conjunction with the School of Agriculture, Cambridge.

The following conclusions were arrived at from preliminary experiments which have been completed :—

(i) There was no difference in shell quality from eggs of birds fed on oyster or cockle-shell.

(ii) During a period extending from June to September the feeding of different levels of protein did not affect the quality of the egg-white.

(iii) The addition of 10 per cent. dried grass under confined conditions appreciably altered the colour of the yolk, but not the quality of the egg-white.

(iv) The replacement of maize meal by wheat meal resulted in paler yolks, but did not appreciably alter the egg-white.

From a survey of the whole flock it would seem that quality of egg-white is an individual characteristic and that there is a seasonal variation in the quality of egg-white.

Statistical Department.

(*a*) A statistical study was made of all data of experiments conducted at the National Institute of Poultry Husbandry (1).

(*b*) Northern Breeding Station.—

(i) A report was prepared on fecundity data for 1930.

(ii) The statistical section of a review of the station's experiments up to 1930 was prepared.

(iii) Advice was given as to the future experimental work at the station.

(*c*) Southern Table Poultry Experimental Station.—

Data were analysed and a report made on average weight at 8 weeks and results of cramming.

(*d*) Harper Adams College Laying Trials.—

A statistical examination was made of monthly egg weights and production of nearly all birds since commencement of Trials (1).

Titles of papers issued during the year.

1. Dudley, F. J.: Short period trapnesting as a means of estimating annual egg production and average egg weight. *Harper Adams Utility Poult. J.*, **16**, 11, 1930–31.
2. Tallent, V.: The marketing of ducklings by toe slitting. *Ibid.*, **17**, 6, 1931–32.
3. ————: The sexing of ducklings. *Ibid*, **17**, 11, 1931–32.
4. ————: The production of table ducklings: barley meal and Sussex ground oats for rearing and fattening table ducklings. *Ibid.*, **17**, 8, 1931–32.
5. ————: Notes on general management of ducks. *S.P.B.A. Yr. Bk.*, 1932.
6. ————: The Problems of duck egg marketing. *Utility Duck Club Yr. Bk.*, 1931–32.
7. ————: Duck Production. *Feathered World Yr. Bk.*, 1932.
8. ————: Blackhead and suggestions for its prevention. *Bronze Turkey Club Yr. Bk.*, 1932.
9. Parkhurst, R. T., and McMurray, Mary: Factors in the development of deformed leg weakness in chickens. *J. Agric. Sci.*, **23**, 311, 1933.
10. ————: The relation of calcium and Phosphorus to growth and rachitic leg weakness in chickens. *Ibid.*, **22**, 874, 1932.
11. Tallent, V.: Pellets v. mash for table duck production. *Harper Adams Utility Poult. J.*, **17**, 11, 1931–32.

(B) Reaseheath: Cheshire School of Agriculture (Northern Breeding Station).

As a note of these experiments has not previously appeared in this volume it may be convenient briefly to record that experimental work has been in progress at this Station since 1924 for the investigation of problems relating to poultry breeding and its effect on egg production, and particularly those touching the effect of inbreeding. Matings, principally with White Wyandottes, have been made with (*a*) father to daughters (whose dam was unrelated to the cock), and (*b*) father to daughters (whose dam was sister to the cock). The pullets resulting from these matings were trap-nested for 12 months—and the results compared with those of outbred "controls" sired by the same cock—but were not retained for further breeding. The matings on these lines have now been repeated over eight seasons. An interim report (Bulletin No. 19, "Poultry Breeding for Egg Production") was issued by the Ministry in 1930 and a detailed

report on the whole series which was concluded in 1932 is in preparation. The data which have been collected at the Station will probably be of great value in throwing light on other problems of breeding than the effect of the father-daughter relationship, and they are now being explored for this purpose. A further programme of experimental work at the Station is now under consideration.

(C) Wye: South-Eastern Agricultural College (Southern Table Poultry Station).

The experimental plant at Wye College was established in the Autumn of 1923, to undertake investigational work in table poultry. The experimental work has been designed to furnish data on the following matters :—

(i) The best methods, for all times of the year, of feeding and marketing birds that are a by-product on commercial egg farms.

(ii) The economic value, for table purposes, of the breeds most generally used by commercial egg farmers, as compared with the breeds and cross breeds generally regarded as the best for table use.

(iii) The amount and value of the weight gained by the various breeds and cross breeds used in the investigations, in relation to the weight and value of food consumed.

The results of the experiments carried out in the years 1925 to 1928 inclusive have been published in the Ministry of Agriculture Bulletin No. 18, entitled "Table Poultry Production." A revised issue of this bulletin dealing with the years 1929 to 1931 is in course of preparation.

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34. SMALL ANIMAL BREEDING STATION, CAMBRIDGE UNIVERSITY.

The various experiments in progress have been continued. The Silver Cambar gives a down distinction in the sexes as clear as that of the Gold Cambar, and next season it should be possible to have the variety fixed for colour. It can then be turned over to Mr. Pease and worked up for improvement in fecundity.

The series of linkage experiments in connection with fecundity has advanced a step in that it is manifest from the work of the past two years that there is no linkage between the sex-linked factor for light shank and any fecundity factor. A further link in this series of experiments is being started to test the linkage relations between light shank and silver. A knowledge of this is essential in connection with the possible, though improbable, existence of a sex-linked fecundity factor.

The breed of dark-downed Runner Ducks designed to give a sex-linked result with Fawns is progressing satisfactorily and should, in two years time at the furthest, be available for more extensive propagation.

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35. INSTITUTE OF ANIMAL GENETICS, EDINBURGH UNIVERSITY.

Poultry.

Avian sex physiology.—The records of data which have been collected systematically for the last three years are now approaching a stage at which an analysis can be commenced and their value and significance expressed. Up to the present about 1,200 normal and 400 experimental birds have been examined. Fortnightly weighings, comb and spur measurements, and plumage examination (including moult phenomena) have been carried out. Weighings and histology of endocrine glands from birds killed at varying ages and seasons of the year have been made. Accurate records have been kept of egg laying, weight and shape of all eggs, maturity, production and laying cycles. With regard to incubation, a large body of figures dealing with hatchability, embryonic mortality and sex ratio is now available.

The value of progeny in relation to age of dam, i.e., the problem of how long it remains profitable to keep hens for breeding purposes, has been examined in the light of data collected on incubation records for the past four years, and hatchability records of hens varying in age from one to seven years have been tabulated. Hatchability fell off rapidly after the third year of the individual's life and was found to be due mainly to a lower fertility of the eggs and to a lesser extent to an increase in the dead-in-shell. Despite the suggestions of some workers to the contrary, it therefore appears that the present practice of breeding from hens in their earlier years only is the best (27).

Data were collected concerning the effect on sex ratio of the time eggs are stored prior to incubation. In a population of 8,647 eggs there was no difference in the sex ratio of eggs incubated during the first and second weeks after laying. Those incubated in the third week showed a slight increase in the number of males but the population in this group was only 242 and the deviation therefore cannot be considered significant.

The comb studies have now been completed. In each of the two sexes there is a definite seasonal cycle in comb size. In the female the moulting period is characterised by a much greater decrease in comb size than is the case in the male ; the points of onset and of disappearance of this comb dip are also much sharper and more marked in the former sex. A total lack of variation was

observed in the comb of the completely castrated birds throughout the year but the presence of small fragments of testis were associated with a faint seasonal rhythm similar to, but much less in intensity than that in the normal male. The behaviour of the comb in birds carrying gonad grafts of their own or of opposite sex was also examined and the relation of their comb cycles to those obtaining in the normal male and female considered. Daily Anterior Pituitary gland implants to females were found to inhibit the normal regression of the comb during the moulting period.

An interesting abnormality which occurred in a Brown Leghorn male in our stock has been described. A male which had been castrated prepubertally and had developed into an apparently normal capon, began to assume female characters (thin lop comb, female plumage and the cessation of the continuous moult typical of the capon) when about 15 months old. The case is discussed in relation to other known cases of sex-reversal, the abnormal appearance being attributed to the influence of a small tumour situated on the right side of the body, posterior to the normal gonad site (29).

Pinealectomy.—A technique has been devised for removal of the pineal gland of chicks a few days after hatching, and a preliminary series of these experiments have been carried out on both males and females with a view to examining their effect on the other endocrine glands and on the secondary sexual characters.

Hormone injections.—A further series of tests and assays of male hormone extracts (by injections to capons) have been made in conjunction with Professor Dodds of the Middlesex Hospital.

Genetics.—Individuals who, in respect of plumage colour, disobey the rules of sex-linked inheritance are not rare. An exceptional gold cock ex Light Sussex × Rhode Island Red has been studied. Genetical and cytological examination has shown that he must have received both his x chromosomes from his father, that he was, in fact, a non-disjunctional male. This is the first case of such to be reported in the fowl.

A plumage character somewhat like frizzling, but genetically distinct from this, is found in exhibition Rhode Island Reds. It is definitely undesirable. Its genetics is being studied.

A peculiar eye condition in the White Leghorn, reminiscent of Leber's optic atrophy, is being studied. The story is complicated by the fact that the character is not expressed until the bird is about six months old, but the condition is certainly genetic.

Turkeys.—Having at length determined the genetic relations of bronze to black, red and white plumage colours in the turkey, it became possible to arrange matings to determine the relations of black, blue, red and white to each other. A large F_1 has been raised. It is of interest to note that with the system of intensive rearing adopted no losses from disease were suffered. In previous years the work has been sadly embarrassed by outbreaks of black-

head and of paralysis. The problems of rearing have now been overcome. An unexpected result was obtained in the crosses White × Buff, for among the offspring were several typical Narragansetts, a variety well known in America but not in Europe. This colour appears to be a monogenic sex-linked recessive character. Three true breeding varieties of blue, two varieties of red, and three previously undescribed colour varieties have also appeared, and their genetic relationship will next be studied.

Ducks.—Whilst in America Professor Crew found that the genetics of the Runner Duck was being studied comprehensively at Wisconsin. He therefore arranged to hand over his records to Dr. Japp since he had gone much further and had greater facilities The work is not of sufficient interest or importance to warrant. duplication.

The study of " feathered legs " in the Aylesbury has been continued. The story is complicated by the fact that not all the ducks with feathers on their legs at hatching retain them when adult.

The species cross, Aylesbury × Muscovy, is being used to examine the problems of sterility in hybrids and of the length of the incubation period.

Cattle.

The study of the inheritance of milk yield is being continued and has formed the principal subject of investigation. In a study of 728 bulls of the Red Danish breeds the records were analysed of some 14,000 cows. The results obtained indicate the probable existence of sex-linked factors concerned with the transmission of milk yield. The Dairy Shorthorn breed has provided the data for another study by the more reliable " squared difference " method of correlation. The advantage of these data is that they are restricted to single herds and that the record of every animal in each herd has been analysed. Thus the two chief criticisms of the results obtained by the same method from the Ayrshire data have been overcome, namely variation due to different systems of management in different herds, and, secondly, that the sample of the population examined excluded the low yielders. The results of the examination of one herd exactly confirm those obtained from the Ayrshire data that sex-linked factors play no unimportant part in the transmission of milk yield. The results from the other herd are not so conclusive. But, as regards both, the final statistical analysis has not yet been completed. This investigation is based on the yields of 1,420 cows which gave over 50,000 pairs for comparison.

A similar study has also been begun of the yields of the cows in one of the largest herds of British Friesians. In connection with this and the other studies the Institute is indebted to private breeders who have allowed the fullest possible access to their records.

At the experimental farm of Shothead the initial matings have been made in an experiment designed to determine the economic importance of the sex-linked factors which appear to affect milk yield. Low yielding beef Shorthorn cows have been mated to dairy Shorthorn bulls of a high yielding strain. The reciprocal cross has also been made.

From the herd of Ayrshire cattle at Shothead some information has been obtained concerning the economy of milk production. These are based on the records of 9 heifers all by the same bull.

9 cows averaged 1,000 gallons at an average food consumption of 4.2 lb. of production ration per gallon of milk produced.

Cow " A " gave 1,100 gallons on a consumption of 3.75 lb. of production ration per gallon of milk.

Cow " B " gave 1,150 gallons on a consumption of 4.45 lb. of production ration per gallon of milk.

For 1,100 gallons of milk cow " A " produced the quantity for nearly £3 less value of food than cow " B."

A study of the relation of conformation to production has been commenced and routine measurements are made of all the dairy cows and heifers in the Shothead herd.

A weekly analysis is made of the morning and evening milk of each cow in respect of butter fat and specific gravity. The results have not yet been analysed as only a small proportion of the cows have finished their first lactation on the farm.

In conjunction with the Imperial Bureau of Animal Genetics, a complete review of the literature of the inheritance of milk yield has been made and will be published shortly. Without the provision of a grant of money from private sources it would not have been possible to have made either this review or the statistical analysis of the inheritance of milk yield.

A study has been made of the construction of the Shorthorn breed of cattle. During the past five years there has been a significant decrease in the amount of inbreeding. Internal evidence shows this to be due to the increase in numbers of animals of the dairy type which consequently have a lower concentration of the blood of the beef or " Scotch " Shorthorn.

Horses.

A study of the Clydesdale breed is in course of preparation for the press. This deals with the breed as a whole, and with prize-winners and horses which, owing to defects, have been refused licences.

The stud of Shetland ponies has been retained and mares have been provided for Professor Linton, of the Royal (Dick) Veterinary College, for the purpose of an analysis of the composition of mare's milk.

Pigs.

The plant at Shothead has been reduced from an experimental to a maintenance basis on grounds of economy.

Sheep.

The inheritance of wool quality.—During the past months much of the work of previous years has begun to yield tangible results. The preliminary work undertaken was necessary since wool growth and the development of the fleece in Scottish breeds had not received a great deal of attention earlier. Attention was first concentrated upon kemp in the Blackface breed. Collection and subsequent analysis of samples from a very large number of rams, ewes and lambs placed at the Institute's disposal by breeders in many parts of Scotland has revealed some very important facts during the year under review. It has been shown that the number of kemp follicles present in a particular sheep is determined by its genetic constitution, and that the sire is responsible to a greater degree than is the dam for both high and low numbers of kemp follicles in the skin of an individual sheep. The amount of kemp fibre present in a fleece, however, depends firstly upon the genetic constitution, and secondly upon the environment of the sheep and its management It is possible, for example, for two rams with the same approximate number of kemp follicles to yield fleeces with very different amounts of kemp by weight if one is kept upon a maintenance ration only and the other is forced for show or sale purposes. In the latter case the amount of kemp by weight is greater. This result is of importance since it indicates that the amount of kemp in the fleece of the show ram is maximal, and, when judged by eye, an over-estimate of actual kemp content of the fleece results. In other words, the show-yard ram will yield progeny whose fleeces under ordinary methods of management will exhibit less kemp than their sire.

Further, we have found that parents with fleeces of equal kempiness will breed true for this character so far as the majority of their progeny are concerned. There will thus become available a mechanism whereby the breeder can, if economic returns from the sale of wool encourage him to do so, eradicate kemp from his stock in all but negligible proportions.

Pigmentation of the fleece.— A great deal more is now known concerning black and coloured fibres than formerly. It has been found that in many cases Blackface lambs which were born self-black undergo a change during the first 18 months to 2 years which results in the fleece becoming first smoky and later white. In some individuals this restriction of pigmentation is assumed rapidly, in others slowly. By breeding tests it is now known that such animals, even though in adult life they appear to be white-fleeced sheep, were in actuality genetically black lambs or lambs with large black splashes or spots. Fleeces from these when carefully

examined show very large numbers of pigmented fibres scattered throughout.

Sheep of this constitution should not be used for further breeding in flocks where it is desired to eradicate colour. Their progeny are " tainted," and once the taint of colour has been introduced by the use of a ram it is exceedingly difficult to control (21). Nearly all sheep which possess this undesirable capacity to breed heavily coloured progeny themselves possess self-black faces and legs, have a collar of black wool round the neck, or show bluish wool near the skin when the fleece is parted over the root of the tail and along the back to the neck.

Inheritance of deformities.—Further work upon several deformities of lambs and the modes of inheritance of these has been completed. The available evidence goes to show that one of these—a condition of stiffened joints in the limbs of lambs which die after birth—is closely analagous to, if not identical with, " club-foot " in human beings. This condition is a simple Mendelian recessive in the sheep, commonest in the Welsh Mountain breed, and evidence is now being collected which shows that it is much more widespread than was at first imagined. It has also been recorded in cattle quite recently. Other genetic deformities which have received attention and upon which work is in progress include absence of lower jaws in lambs (with an incidence of 10 per cent. of lambs born in one particular flock), teatlessness in ewe lambs, and absence of eyes. It is believed that these are simple Mendelian recessivcs, but further evidence is required before definite proof can be produced.

The physiology of reproduction.—Further progress has been made with the study of the fundamental physiological mechanisms of reproduction in the female. Experiments in mid-summer in which ewes of different breeds were kept under conditions of lighting approximating as closely as possible to those of autumn, when the œstral season of sheep normally occurs, yielded negative results. It was, however, not possible to control temperature and feeding so as to imitate autumnal conditions.

This work has yielded many valuable results, but it is not yet completed and it is undesirable to report upon it further at present. It is hoped that from it will emerge information which will establish the reasons underlying the seasonal occurrence of œstrus, the basis of " flushing " ewes before mating, and that further light will be thrown upon the inheritance of twinning and high productivity.

Rabbits.

During the year under review electric heaters have been installed in the rabbitry with a view to allowing the commencement of breeding operations at an earlier date than has been possible so far. It should now be possible to carry out matings at least a month

earlier than could be done in any of the previous years, with the result that more matings will be made during the early spring.

The stock of Angoras has been decreased but sufficient have been retained to provide material for a further study on the effect of increasing age upon the quantity and quality of wool growth. This is a continuation of specific studies of the Angora as a wool producer. To these studies reference has been made in previous reports.

Attention has mainly been directed to fur-bearing rabbits and to the Rex in particular. It appears that facts bear out the belief that the Rex is peculiarly liable to suffer from certain rabbit diseases. It is suggested that the original Rex rabbits were bred from unsound stock from which all Rexes have derived the susceptibilities referred to. It is believed, however, that by careful selection of breeding stock a strain can be established which will be no less hardy and no more difficult to rear than any other type. The method involves rigid selection and crossing with sound stock and thereafter extracting the Rex character again. Investigations concerning the inheritance of the different types of coat in the Rex have been continued and have been extended to include other varieties. These investigations will take a considerable time to complete but it is anticipated that some interesting results will be obtained. Several new colours of Rex rabbits are being produced. The first generation has already been reared. The colours aimed at include the Japanese, Chinchillated Japanese, Smoke Pearl and Lilac. These should be obtained in the next generation which will be born in the spring of 1933.

Crossing is being carried out with a view to demonstrating the genetical constitution of the Smoke Pearl rabbit. So far it has been identified as a light Chinchilla showing dilution in combination with the tan pattern or self, but some other character, so far not identified, is present.

Several new recombinations of characters are being made in the belief that the resulting varieties will be of use to the fur trade. These include the dilute Brown Agouti, known as Opal.

A second case of somatic segregation in the rabbit was presented to the Institute. The animal is a black Dutch buck which shows an expanse of dilute blue pigmentation in the white area close to and actually reaching the black saddle. It is hoped to breed from the animal during the forthcoming spring. The results obtained should prove of very great interest if the mosaic condition is inherited as was the case in a similar occurrence reported by Castle. The condition was not inherited in the only other recorded case. This was a shorthaired rabbit with several patches of Angora fur. It was presented to the Institute in 1927.

The collection of data relating to the effect of certain factors on litter size, duration of pregnancy, sex-ratio and fertility of coitus, has been continued. The additional records obtained during the

year confirm the conclusions drawn previously and published in an interim report. (World's Poultry Congress, 1930.)

A representative of the Institute attended the meeting of the British Fur Breeders' Association, 1931, the Bradford Rabbit Breeders' Meeting and Show, 1932, and the Harper Adams Rabbit Conference, 1932. It is pleasant to record also that very many enquiries have been received from breeders all over the country, and these enquiries have been dealt with through the post.

Titles of papers issued during the year.

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36. (CROP AND) ANIMAL HUSBANDRY DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Young beef.—A study of various systems of feeding and rearing for the production of young beef, has been made over a period of four years. The dams were all cross-bred Galloway cows and they were mated each year with a pedigree white Shorthorn bull. In each of the systems of rearing adopted the calves were suckled by their dams for approximately 6 months and were disposed of fat at ages of 14, 16 or 18 months according to the method of fattening employed.

An account of the systems adopted, the live weight increases of the calves for the various periods of their lives and the cost of

production in each case has been prepared and is awaiting publication.

Yield and composition of milk.—An investigation of data from the dairy herd of the Agricultural Research Institute, Hillsborough, has been completed and published during the year, in collaboration with the Chemical and Animal Nutrition Division (see page 205). For a complete year, from February 1929 to February 1930, the yield of milk at each milking from each cow was recorded and sampled, the percentages of butter fat and of solids-not-fat being determined on each sample. Meteorological records were also kept. The data were analysed by statistical methods, using direct correlation, the correlation of first differences, and partial correlation to determine the relationship between the yield of milk from the herd and its composition, and between climatic conditions (temperature and humidity) and the yield and composition of the milk. The results are set out at length in a paper (1). Probably the most interesting finding is that there was little or no connection between day to day variations in temperature and humidity and day to day variations in the yield and composition of milk.

Keeping qualities of eggs.—An empirical investigation of factors affecting the length of time eggs remain fit for food was commenced in January 1931, and is continuing in collaboration with the Egg Inspectorate of the Ministry of Agriculture (N.I.). The eggs from certain pens on the poultry farm of the Agricultural Research Institute, Hillsborough, are kept every Sunday throughout the year. The quality of these eggs is determined by candling on the following day, and they are stored on the farm and candled each Monday until they are unfit for food, complete records being kept of the appearance of each egg at each test. Observations are also made at other farms and cases of eggs have been sent through the usual trade channels and returned to the farm. Certain of the eggs are tested for strength of shell at the Chemical and Animal Nutrition Division. The data so far accumulated suggest that the feeding and management of the hens within normal limits have little effect on the keeping quality of the eggs, nor does the appearance of the egg when fresh give any useful indication of its keeping qualities. There also seems to be but a small connection between the strength of the shell and the keeping of the eggs. Eggs transported by road and sea are found to have deteriorated in appearance on returning to Hillsborough, but on subsequent storing on the farm they are found to be little affected in their keeping qualities.

Title of paper issued during the year.

1. Houston, J, and Hale, R. W. : The yield and composition of milk with special reference to the influence of climatic conditions and other factors. *J. Dairy Res.*, **3**, 2, 294, 1932.

H.

DAIRYING.

37. NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING.

Husbandry.

Inheritance and milking ability, and the production of butter fat and solids-not-fat.—The collection of data for the study of the inheritance of dairy qualities in cows is being continued, and the 10-year-old stock bull mentioned in the report for 1930–31 is still being used.

Work on this problem during the current year has been concerned chiefly with the development of methods for expressing the lactation yields of solids-not-fat in the milk of individual cows. At present the work has not reached a stage where final recommendations can be made, but the value of the different methods is being tested.

Calf feeding.—A mixture of dried separated milk and dried whey was tried as a substitute for whole milk. The dried products were mixed in the proportion of 3 and 2 respectively and reconstituted by mixing $1\frac{1}{2}$ lb. of dried products with 1 oz. of cod-liver-oil and one gallon of warm water. The nutrients in this mixture closely approximated to those supplied by 1 gallon of whole milk. A second milk substitute was prepared in the same manner, except that a dextrose food was used instead of dried whey.

Bull calves for veal were given these foods in gradually increasing quantities from the 21st to the 49th day of age. The daily live weight increases were about $1\frac{1}{3}$ lb., which cannot be regarded as a satisfactory standard for veal calves.

Two heifer calves, reared on the dried separated milk and whey diet from three weeks old, made satisfactory progress.

The health of all the calves was excellent, except that slight scouring occurred when the liquid given exceeded 6 quarts per day; on reducing the amount of water without reducing the solid food ration all traces of scouring ceased.

The general conclusions from the limited number of animals used in these experiments indicate that when whole milk is very scarce the mixtures noted above provide useful alternative foods for young calves. The method cannot be recommended as entirely satisfactory for the production of veal.

Winter feeding of young dairy cattle.—During the winter of 1931–32 seventeen yearlings were divided into three groups, which were fed as follows:—

(i) A control group which received a mixed diet conforming exactly in nutrients and balance to the ration standards recommended by Henry and Morrison. The diet was adjusted, according to the live weight of the animals, every fourteen days.

(ii) An underfed group which received the same diet, but every ingredient reduced by 10%; and
(iii) An overfed group which received the same diet, but every ingredient increased by 10%.

The daily live weight increases of each group were: overfed, 0.97 lb.; control, 0.84 lb.; underfed, 0.56 lb.

The condition and health of the two well-fed groups were very satisfactory; the underfed group maintained good health and moderate condition, but there was more robbing of food by the master animals. The results obtained showed that the feeding standards may safely be used under English conditions.

Causes of removal of cows from dairy herds.—This investigation, which was commenced in October, 1929, has been continued throughout the year.

A second interim report on the data collected during the year ending October 1st, 1931, has been prepared and will be published shortly. This report shows the relative importance of various causes of disposal from a population of 13,000 cows in the counties of Berks, Bucks, Dorset, Hants, Northants and Oxon. Some special points connected with this work were communicated to the Agricultural Education Association at its meeting at Edinburgh in July, 1932; a précis of this paper will appear in "*Agricultural Progress*," Vol. 10 (1933). The data collected during the year 1931–32 will be analysed as soon as all of it is available.

This investigation, which has been assisted by a grant from the Ministry of Agriculture, is on similar lines to that carried out at the School of Agriculture, Cambridge, with whom close co-operation is being maintained, to ensure uniformity of methods.

Tests of milking machinery.—In addition to tests of milking machines carried out for the Ministry of Agriculture's Machinery Testing Committee, other items which have received attention during the year include:—

(i) Comparison between the milking speeds of machines fitted with old and new teat cup liners. This work has shown that slower milking results from the use of old teat cup liners and has demonstrated that excessive economy in replacements of these rubbers is unwise.
(ii) Preliminary tests of the influence of changes in vacuum pressure on milking speed.
(iii) Trials of sundry minor adjustments and attachments for milking machines. While some of these deserve encouragement and development, there is nothing of outstanding practical importance to report.

Two milking machines normally remain in regular use on the farm; these are changed from time to time and enable us to obtain additional knowledge of milking machines as well as detailed knowledge of certain aspects of their use.

Manufacture of silage by the A.I.V. method.—A wooden silo of the type used in Finland was erected and filled with green lucerne, treated according to the A.I.V. method, in the autumn of this year. Samples of the green crop were taken at the time of filling, and further samples will be taken when the silo is opened during the winter. If possible, the value of the silage as a food for dairy cows will be investigated. This work is being carried out in co-operation with the staff of the Imperial Chemical Industries Research Station.

Husbandry and Chemistry.

A study of typical English milk.—This work, which was reported last year, is being continued and expanded.

Some of the results obtained in the first three years provide material for two papers in the *Journal of Dairy Research* (1932, 4, 48).

Special attention is being concentrated on the changes which take place in milk when the cows pass from winter feeding to grazing. With our typical herd the drop in the percentage of fat in the morning's milk is a most noticeable feature. The percentage of fat falls below 3 per cent. for a considerable period each year in the spring. At this period (March 17th–May 25th) a more detailed and frequent study was made of the various constituents and of the specific gravity but by far the most marked changes were those associated with the physical and chemical properties of the fat.

Prof. T. P. Hilditch has extended his studies of the changes in the glyceride structure of the butter fats during this period.

The marked changes in amounts of the fat-soluble vitamins and carotene in the milk (see below) are also being investigated this year.

The distribution of the nitrogen between the casein, albumin, globulin and other nitrogenous substances has been determined in weekly samples and the variations appear to be very small.

The copper and iron contents have been determined monthly and do not appear to show any seasonal variation. The relation of chloride to lactose content in the typical milk has been studied. It appears that the chloride content might serve as a " single value " for gauging milk composition.

This also bears on the freezing point of the fresh milk, which has again been shown to be so constant as to fall almost within the limits of experimental error.

The exact seasonal differences, if any, in the freezing point of this milk will be further investigated when the arrangements for still further improving the calibration of the mercury thermometers are completed.

Chemistry.

The solids-not-fat content of milk.—The freezing point of abnormal milks which have been studied has never failed to distinguish these from watered samples.

For this work samples of the milk from a Hampshire herd

known to be low in solids-not-fat have been of great value. The arrangements with the Advisory chemist for the Reading Province have been continued and the milk from this herd is brought to these laboratories by Mr. Lesser, who is carrying out the investigation.

Further investigations on the chemical composition of milk low in solids-not-fat have consisted of the determination of casein, albumin, globulin and non-protein nitrogen in ranges of samples of varying quality. It has been found that a lowering of total nitrogen, protein and casein nitrogen occurs with lowering of solids-not-fat. With samples of uniformly high solids-not-fat content the nitrogen distribution is very regular and 6 per cent, of the total nitrogen only is non-protein nitrogen and 80 per cent. of the protein nitrogen is casein nitrogen. The albumin and globulin are also constant. With lowering of solids-not-fat the non-protein nitrogen may increase to 15 per cent. of the total nitrogen, the casein only accounting for 66–75 per cent. of the protein nitrogen, and the albumin and globulin nitrogens are high and variable in amount. High chloride content of milk is accompanied by high non-protein nitrogen (8).

Metallic contamination of dairy products.—Extensive data on the amount of contamination of various dairy products by copper and iron have been collected from work carried out during the past four years. Data on uncontaminated samples indicate that the natural copper and iron contents of English milk are 0.5 and 2.0 parts per million respectively (3). Considerable contamination of milk can occur during processing in worn plant, and from a large number of samples it has been deduced that a total copper content of 1.5 parts per million is likely to cause oxidative taints to develop in good quality milk kept under ordinary commercial conditions.

Lipase in butter.—Some work on the destruction of the lipase in unpasteurised sweet cream butter by traces of heavy metals (11) has revealed that the rate of destruction of the enzyme varies with the amount and type of contaminating metal. The rate of destruction of the lipase has been found to run parallel with the capacity of the metal to induce oxidative changes in the butter on further storage. Peroxide formation in butter in which lipase is present runs parallel with the increase in acidity during the first 7 days of keeping the butter, this being due to the liberated oleic acid. The amount of peroxide reaches a maximum at which stage all lipase activity ceases. Traces of heavy metals inhibit lipase activity to varying extents and the concept of the lipase acting as an anti-oxidant of the fat proper for a short time in the life of the butter has been suggested.

Deterioration of the fat in foodstuffs.—Papers on this subject have been published (6).

Molassed beet pulp.—With the assistance of Mr. H. C. Dowden, whose services were lent by one of the group of beet sugar factories to help in the investigations on the alleged fishy taint in milk through

the feeding of molassed by-products, a considerable amount of research has been carried out on the methods for determining betaine in sugar beet by-products. A simple and satisfactory method has been evolved and applied to samples of molasses and molassed pulp collected from eleven factories in England. The results of analysis prove that the betaine contents of both by-products are uniform for the range of factories and that betaine does not suffer much breakdown during the treatment in the pulp-drier. Other investigations have proved that betaine requires drastic treatment before it yields trimethylamine. Such methods as alkaline pyrolysis or alkaline oxidation are necessary for some trimethylamine to be formed and even then over half the nitrogen is changed to ammonia.

Cheese.—In collaboration with the bacteriological department, the chemical side of investigations into the fundamentals of cheese ripening have been undertaken. Preliminary work of a biochemical nature involving an assay of rennet enzymes under various reaction conditions has already been attempted (2) and the analysis of a number of experimental cheese involving studies in the following directions:—(*a*) oxidation-reduction equilibria, (*b*) special starters, (*c*) rennet enzymes effects, (*d*) enzyme activator experiments, and (*e*) oxidant experiments, are in progress. A paper on detection *in situ* of tin solder causing dark discolouration in cheese has also been published (7).

Fodder analysis.—Co-operative work in conjunction with the unification (standardisation) of the methods of analysis of forage crops undertaken by the Agricultural Education Association has been carried out.

Silage experiments.—Chemical analyses on the A.I.V. silage have been conducted (see p. 227).

Preliminary experiments including pig feeding experiments have been started on the preservation of lawn mowings with acid whey.

Nutritional value of raw and heated milk.—Experiments on the feeding of rats with raw and heated milk as a possible means of demonstrating changes in nutritional values are still in progress.

The feeding of "sterilised" milk has been discontinued as no generation beyond a second could be weaned, but a corresponding group receiving raw milk has continued to breed and lactate through successive generations, a seventh having now been raised.

The feeding of corresponding groups of rats on raw milk and on milk which has been heated to 145–150°F. for half an hour is being continued. Estimations of hæmoglobin and the number of red cells in the blood and also analyses of the bones of the animals in both groups are being carried out.

Work on lactation.—The study of the dietary requirements for successful lactation in rats mentioned in the previous report has been continued in collaboration with the Department of Physiology

and in association with the Department of Biochemistry, University of Oxford. A large incidence of lactational failures in seemingly normal female rats was obtained when two diets mainly consisting of natural foodstuffs were fed. The results are still irregular and much more work will have to be done on this complicated problem before any conclusions are reached.

Work on refection.—After a temporary delay the work on refection carried out in collaboration with the Bacteriological Department is being resumed. In the meantime rats have been maintained in good health for over a year and a half on refective diets devoid of the B group of vitamins and have reached a weight of nearly 400 g. (males).

The vitamin content of type milk as affected by the season and the nutrition of the cow.—This study, planned for a period of at least two years, was started in January, 1932. The mixed milk of the typical herd is used, aliquot samples being blended daily from the morning and evening milkings in the proportion of 3 : 2. For the purpose of the experiment each year is divided into three main periods, (*a*) the period of winter (stall feeding) extending, so far as the feeding experiments are concerned, from about the middle of January until the middle of April, (*b*) the summer (grass feeding) period, ranging from the middle of May till the first days of August, (*c*) the intermediate autumn period when grass is becoming scarce and has to be supplemented with kale, cabbage and hay. In the course of each period the following vitamins were estimated :— Vitamin A, Vitamin B_1, Vitamin B_2, Vitamin B complex, Vitamin C, Vitamin D, and Vitamin E. For the purpose of estimating the fat-soluble vitamins A, D, and E, the cream from "type" milk was churned at frequent intervals and the resulting butter was melted as soon as possible in a steam oven. The fat, separated from the aqueous layer and filtered, was stored at low temperature and used for feeding. The remaining vitamins were estimated in whole milk. Vitamin A was estimated by the degree of growth produced in the course of five weeks by graded amounts of butter fat administered to young rats which had been depleted of their Vitamin A reserves on a Vitamin A deficient diet. The International Vitamin A standard (carotene) obtained from the National Institute for Medical Research was used as reference substance. The Vitamin B_1, Vitamin B_2 and Vitamin B complex contents of the milk were measured by administering in the course of eight weeks graded amounts of whole milk (from 2 to 16 c.c.) to young rats subsisting on dietaries deficient in Vitamin B_1, B_2 and B complex respectively. A potent brewer's yeast was used as standard of reference. Later the International Vitamin B_1 standard was also used. Vitamin C was estimated on guinea pigs by the method of Höjer. Vitamin D was estimated in butter fat fed to rats both by the curative and

protective technique, the line test as developed by Steenbock being used in the former, while the mineral (ash) content of the bones was estimated in the latter. The International Standard of Vitamin D was used as reference substance. A method has been devised lately for the feeding of the non-saponifiable fraction of butter fat and will be used in testing butters of low antirachitic potency (winter butters). Attempts have been made in curative tests to estimate the Vitamin E potency of butter both by feeding butter fat and the unsaponifiable residue from butter fat. These attempts have so far not been successful, no " cure " being produced, even by the highest dosage, most probably owing to the very low Vitamin E content of butter. It is hoped to gauge this Vitamin E potency in protective experiments. It is planned to continue the experiment for at least another year and it is premature at present to state the results of the individual tests. It may be stated generally that the difference in Vitamin A and D values between summer and winter milk is very marked, while the fluctuations in the Vitamin B group values are much less intense. About 700 animals, rats and guinea pigs, have been used in the course of the first year.

Chemical estimation of Vitamin A and of carotene.—Parallel with the biological estimation of Vitamin A and its precursor carotene in " type " milk these two constituents were also estimated by chemical and physical methods. The yellow colouration of butter fat and of the non-saponifiable residue as well as the blue colouration with antimony trichloride were estimated twice weekly in the course of the year. Besides the quantitative increase of yellows and blues in summer butter as compared with winter butter, a qualitative difference was also found. The presence of a substance or property in summer butter inhibiting the $SbCl_3$ reaction and removed on saponification has been demonstrated. This problem is being further studied in collaboration with Dr. T. Moore of the Nutritional Laboratory, Cambridge.

Study of abnormalities occurring in experimental animals.—It has been noticed that in apparently healthy litters in our stock colony of rats some young fail to suck properly and eventually die. The abnormality becomes manifest about the 8th day of lactation and death ensues within the next few days. This phenomenon, possibly a hereditary factor, is being studied in collaboration with Professor F. A. E. Crew of Edinburgh.

Stock colony.—Our stock colony of rats has been lately considerably increased to meet the growing demand for experimental animals. Over 1,500 rats have been produced in the course of the last two years.

Statistical data.—Various data concerning the growth, fertility, size of litter, longevity, etc., of the stock colony of rats have been accumulated during the past year.

Disposal of by-products.—The evaporating and preheating apparatus for drying whey mentioned in previous reports is giving good results on a practical scale; it is also being tried in another dairy for the purpose of drying full cream milk. The latest developments are described in a paper by Golding and Rowsell (12). Pig feeding experiments on the value of this roller-dried whey have also been carried out during the year.

Bacteriology.

Cheese.—Ripening of hard cheese—lactic acid bacteria.

Nitrogen metabolism.—Further progress has been made in the study of this aspect of bacterial metabolism and the earlier findings that the streptococci and lactobacilli differ fundamentally in their nitrogen requirements have been confirmed (15).

Oxidation-reduction potential.—In addition to various oxidation-reduction indicators which give an idea of the conditions obtaining during the course of ripening in cheese, various oxidising and reducing substances have been added to cheese and the effect on the process of ripening estimated by chemical analysis of the protein degradation products (16).

Biochemical characters of lactobacilli.—The biochemical reactions of lactobacilli isolated from cheese are being studied.

Amongst these reactions that of the organisms on litmus milk appears to be characteristic, but it is necessary to establish the constancy of the changes by examining a number of strains from different sources.

Red spot.—The characters of the organism responsible for this fault and some of the conditions governing its appearance have previously been described. The effect of various oxidants such as KNO_3 and reducing substances like KCN, has been observed. The earlier findings of the effect of the associated flora have been confirmed.

Further extensive experiments to discover the ultimate source of the organism have been carried out and have lent weight to the earlier suspicion that the udder was the source. Samples taken from a number of cows have, on addition of the necessary stimulating organisms, been found to contain the organism causing red spot. This does not necessarily imply that good cheese cannot be made from milk containing the red spot organism, as, if conditions of cleanliness are observed and extraneous organisms excluded, the fault may be kept under control.

Stilton cheese.—A series of experiments designed to establish the effect of pricking and the addition of extra salt on the blueing of this cheese was made.

Acting on the knowledge that, in a mixed flora, micro-organisms heavily endowed with catalase grow well in the presence of traces of copper, to the partial exclusion of those not so endowed, some

cheese were pricked with a copper wire, others with ebonite covered wire, whilst the controls were left unpricked. As early as June, 1930, an attempt was made to adapt X-ray photography to the observation of the stages in the development of the " blue veins " but it has not yet been possible to elaborate this method. A method such as this is necessary before the work can show much progress, since boring the cheese admits air and thus automatically marks the end of the experiment. The observations are thus incomplete but in many cases in the pricked cheese some putrefaction was observed along the lines of pricking. In cheese made from " clean " milk it has often been observed that some of the characters of first class cheese are lacking and faults may be pronounced. In this experiment it is believed that the putrefaction observed is due to the fact that clean milk had to be accumulated over several days to secure the necessary bulk. The flora of such milk is believed to be unsuitable for the production of good cheese.

Examination of the pressure expressate of cheese at various stages of ripening continues to yield valuable results.

Butter.

Blue-black or reddish-violet discolouration.—The presence of blue-black or reddish-violet areas in samples of butter after removal from cold storage was traced to the action of bacteria of the pseudomonas type. Two related strains, isolated from the samples of butter, grew well and produced a blue-black pigment at the temperature of the cold store (1°–3° C.). Growth was more rapid at higher temperatures (optimum 20°–30° C.) but the pigment was not produced at temperatures above 10° C.

The pigment occurred as small blue-black aggregates deposited outside the cells (the cell contents were also often definitely blue) and also as a red to brown diffusate through the medium. The latter was produced at all temperatures, the former only at temperatures below 10° C.

The metabolism of these organisms appears to present some special features. Proteose nitrogen was favourable for growth but not for pigmentation. Amino-nitrogen was favourable for both. Milk was slowly digested but the digestion was more rapid in litmus milk and was very markedly hastened by the addition of 1 per cent. NaCl. The addition of NaCl (or other very similar compound) appeared to be essential for the growth of these organisms but its action can probably be explained on physical or chemical grounds (e.g. osmotic pressure, availability of salt-soluble compounds).

Experimental butter was made in which the organisms were added, (i) at the time of making, (ii) at the time of salting, (iii) at the time of reworking after low temperature storage (14°–15° F.). Typical discoloured areas were not produced even after further storage at 1°–3° C.

Milk.

Sterilised milk.—Carbolic taint.—A considerable amount of advisory work has again been carried out during the summer, and further information has been gained of possible sources of infection at the dairy. Advice has been given as to sterilisation of bottles and other dairy equipment, and sometimes with regard to re-arrangement of the dairy, and where this advice has been closely followed a fall in the number of tainted bottles of milk has resulted. With thorough application of control measures during an epidemic and careful control throughout the winter it should be possible to eliminate the cause of the trouble.

The work on the resistance of the spores has been continued. It has been found that the addition of NaCl to the NaOH solution increased the efficiency of the latter as a disinfectant.

The organism causing the " carbolic " taint has been studied in greater detail and has been found to exist in three forms. The sporogenous form, which occurs in bottles of tainted milk, is unstable and during normal growth gives rise to two asporogenous forms. Of these, one is stable, and strains have been cultivated in the laboratory in the asporogenous state for over five years without showing any sign of reverting to the original sporogenous form ; the other appears to be an unstable intermediate form. All three forms are identical so far as cultural characteristics are concerned but can be distinguished from one another on morphological grounds and by the colony forms produced on agar and gelatine media. Serological work has shown that they are antigenically related to one another. They may, therefore, be regarded as variants of a spore-forming species as yet unidentified.

A strain of B. cloacæ isolated from cheese milk.—This organism was isolated from milk used for cheese-making. Part of this had been stored for 48 hours in order to obtain the required bulk. The plate count of the milk (on standard agar at 37°C.) was not abnormally high (15,900 per 1 ml.) and *B. coli* was present in 1/100 ml. The cheese curd, however, was very gassy and rapidly became impregnated with " pinholes."

The milk had also been plated on beer wort agar and incubated at 20°C. and by this method a plate count of 875,000 per 1 ml. was obtained. The colonies on beer wort agar appeared to be a practically pure culture of a strain of *B. cloacæ*. Like the type strain, this was motile and liquefied gelatine very slowly, but it differed in growing better at 20°C. than at 37°C. When first isolated, acid but not gas was produced in milk or sugar solution at 37°C., whereas very vigorous gas production took place at 20°C. After several months of artificial cultivation a slight gas production could be observed at 37°C. but this in no way equalled the gas production of the type strain.

Pasteurised milk. Value of the coliform test.—At present, tests

for coliform organisms are required for the official examination of graded raw milk, but they have been omitted from the tests for pasteurised milk.

It has been found over a series of years, in many different towns and with various types of holder pasteurisers, that coliform organisms were invariably absent from quantities of 1 ml. in samples taken directly from the holder after heating at 145°F. for 30 minutes.

Large numbers of samples of the same milk taken at points subsequent to heating were often found to contain these organisms, sometimes in fairly high dilutions. It is clear that this is due to recontamination during the processes of evacuating the holder, cooling, bottling and capping. It appears that the re-imposition of a test for coliform organisms which are easy to detect would be a further safeguard and promote greater efficiency in the care of plants.

No support has so far been obtained for the contention of some American writers, that there are strains of coliform organisms able to resist pasteurisation (in England 145°F.–150°F. for 30 minutes). However, there is no reason to doubt that an occasional strain will occur, a very small percentage of the individuals of which will resist pasteurisation. But the numbers remaining must generally be very small and the imposition of the requirement that coliform organisms shall not be present in 1/10 ml. would cause no embarrassment to those pasteurising milk.

Observation of gas formation in the test media should not be made until after 72 hours' incubation since any organisms which might survive may be attenuated.

The value of coliform tests in pasteurised milk control has recently been well brought out by McCrady and Langervin, whose work confirms our own.

Media for plate counts of milk.—Further experience with the simple standard agar to which milk has been added at various points during making has confirmed its superiority over the other media used (17) and a milk agar medium has been put into use by Advisory Dairy Bacteriologists as a tentative measure pending final confirmation.

It has also been found that in many cases a greatly increased count results from 66 hours incubation at 32°C. instead of 48 hours (17).

A counting chamber for plates, incorporating daylight lamps, has been perfected and has been found to reduce the error of enumeration of colonies.

Estimation of keeping quality by a modified methylene blue reductase test.—Johns has proposed a modified methylene blue test in which samples are incubated for a period of hours at 55°F. before adding the dye and proceeding as usual.

In this laboratory methylene blue is added immediately and the samples held at 15.5°C. It has been found to date that the keeping

quality as estimated by taste and that found by methylene blue reduction correlate very well. If the modified reductase test could be used the personal factor in the present tasting test would be eliminated.

In view of the importance of the coliform test as a measure of contamination of milk it seemed desirable to attempt the differentiation, using modern technique, of those organisms yielding acid and gas in a lactose bile salt medium. In a preliminary survey of the organisms isolated from routine fermentation tubes it was found that of 55 strains only 14 were fæcal *B. coli* and 11 *B. ærogenes* or *B. cloacæ*, 30 being intermediates when classified by the usual tests.

By repeatedly plating the 55 strains isolated and finally taking two colonies from each plate it was found that the distribution became :—

B. coli	58
B. ærogenes and *cloacæ*	46
Intermediates	6

The intermediates so obtained resisted all attempts to resolve them further.

It seemed possible that the bile salt used in the medium for the presumptive test might have had a selective action on coliform distribution, and the work was repeated by plating directly from milk. Of the coliform organisms isolated by this method only 4 out of 37 proved to be *B. coli*. *B. ærogenes* accounted for 13 and " intermediates " for 20. The latter could not be shown to be mixtures of two or more coliform types.

It seems clear from the above results that in many cases the coliform organisms responsible for the formation of acid and gas in the presumptive test are not fæcal forms, and that the medium itself is somewhat selective in its action on the organisms in milk. It also seems that as shown by direct plating there is amongst the coliform flora a substantial proportion of *B. aerogenes* in milk—a proportion which in these investigations was greater than that of *B. coli*. In an investigation of a number of coliform colonies picked from plates made from dung samples 44 out of 47 proved to be fæcal *B. coli* and only 3 *B. ærogenes* or " intermediates."

Viability of the bovine tubercle bacillus.—It has now been shown (18), as the result of preliminary experiments, that cultural methods, following the action on infected material of various concentrations of H_2SO_4 as proposed by Corper and Uyei for human material, are not applicable to the diagnosis of tubercle bacilli in milk, although the work of these authors with human pathological material was confirmed.

It was found that in infected dung, bovine tubercle bacilli remained alive for at least 178 days in the open in the south of England. The summer of 1931 was, however, characterised by lack of sun and by excessive rain, and the experiments were therefore

repeated. The later results are of course not yet available. Following the success of an experimental technique for the recovery of tubercle bacilli from growing grass it was shown that the grass remained infective for at least 49 days from the time of infection. It is of interest to note that 6.47 inches of rain fell during this period.

An experiment on the possibility of infection of guinea-pigs (as a preliminary to calf-feeding experiments) fed on growing grass infected with known numbers of tubercle bacilli has been undertaken, but the results are not yet available.

Physiology.

External conditions as affecting milk composition.—The collection of data is being continued and has been extended to include in a few cases daily analyses of the milk of individual cows. More of these analyses are obviously desirable.

Studies on blood composition in relation to milk secretion.—The results of this work to date seem to justify the tentative conclusion that the ratio fat : solids-not-fat in milk is dependent on the ratio diffusible calcium : sodium in the blood. Efforts are being made to determine the ionic strengths of calcium and sodium in the blood, which should be of greater significance. The data already obtained, though admittedly incomplete, support the theory that cell membranes are emulsoid in character and are capable of reversible change from a water-in-oil to an oil-in-water type of emulsion with variation in the proportion of divalent and monovalent ions. They are of general physiological application as well as being of special interest in milk secretion, and may provide an explanation of such problems as the differences in fat content of the milk of different breeds, e.g. Shorthorn and Guernsey.

A preliminary report has been published (19) and a fuller account is in the course of preparation for publication. A grant towards the cost of apparatus has been received from the Government Grant Committee of the Royal Society.

Tests for abnormality of milk and of the udder.—On the basis of the generally accepted statement that normal milk contains no blood albumin, work has been started to devise a method of testing for this substance in milk. At an early stage in this work it was found that traces of blood albumin occurred normally in milk, so that other lines are being investigated, with a view to detecting abnormalities in the udder which may not be recognisable by methods at present in use.

Study of cases similar to milk fever, tetany or "Herefordshire disease."—Advice has been sought, and several blood and milk samples analysed in connection with cases simulating tetany or milk fever in milch cows. Similar cases have been reported in the press under the title "Herefordshire disease." The occurrence of the cases investigated has not been confined to the first week of

lactation, nor do the results show that the symptoms are always associated with the lowering of blood calcium, which is generally considered to be a characteristic of milk fever.

Nutritional requirements for lactation.—The first attempts to produce failure in milk secretion by experimental variations of the diet yielded promising results, 46.7 per cent. of the second generation of experimental rats having failed at their first littering. At subsequent litterings, however, there has been a progressive improvement in lactation, possibly due to the fact that it was considered wise to give an increased supply of vitamin B which may have been slightly deficient in the original diet. The work is being continued in close association with the Chemical Department of the Institute and the Biochemical Department of the University of Oxford.

An intensive *post-mortem* study is being conducted on all animals in the rat colony which show habitual failure to nurse their young.

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1. Staff of the National Institute for Research in Dairying : Studies concerning the handling of milk. 4th edition. *Bull.* **31**, *Min. Agric.*
2. Moir, G. M. : The effect of heat upon the rennin coagulation—II. *J. Dairy Res.*, **3**, 1, 80–85, 1931.
3. Davies, W. L. : Observations on the copper and iron content of milk and other dairy products. *Ibid.*, **3**, 1, 86–92, 1931.
4. Bartlett, S. : The feeding and growth of young dairy stock. *Berks. Farmers' Yr. Bk.*, 1932.
5. Mackintosh, J. : The feeding of dairy cows. *Bull.* **42**, *Min. Agric.*
6. Davies, W. L. : The deterioration of the fat in foodstuffs. *Food Technology*, Vol. 1, 4, and 5, 1931, 1932.
7. ———— : Detection in situ of tin solder causing dark discoloration in cheese. *Analyst*, **57**, 671, 95–96, February, 1932.
8. ———— : The determination of chlorides in dairy products and biological material. *Ibid.*, **57**, 671, 78–85, February, 1932.
9. Hoy, W. A., and Newland, L. G. : Value of laboratory control to dairymen. *Dairyman*, **57**, 7, 338–340, February, 1932.
10. Mackintosh, J. : Eradication of tuberculosis from cattle herds. *J. Roy. Agric. Soc.*, **92**, 43–62, 1931.
11. Davies, W. L. : The inactivation of lipase in dairy products by traces of heavy metal salts. *J. Dairy Res.*, **3**, 2, 254–263, 1932.
12. Golding, J., and Rowsell, E. : An auxiliary evaporating and preheating apparatus for drying whey, milk and other liquids by the roller process. *J. Dairy Res.*, **3**, 2, 264–271, 1932.
13. Lesser, C. E. : Milk deficient in solids-not-fat. An investigation on a herd of cows in Hampshire. *J. Min. Agric.*, **39**, 4, 340–345, July, 1932.
14. Boyes, K., and McClemont, J. : Methods of hand-milking—a comparison. *Ibid.*, **39**, 6, 541–544, September, 1932.
15. Davis, J. G., and Mattick, A. T. R. : Studies in the metabolism of the lactic acid bacteria. I. Nitrogen metabolism. *J. Dairy Res.*, **4**, 1, 81–90, 1932.
16. Davis, J. G. : Studies in Cheddar cheese. I. The oxidation reduction potentials of ripening Cheddar cheese. *Ibid.*, **3**, 2, 241–253, 1932.
17. Hiscox, E. R., et al : The bacteriological examination of milk. I. Modification of the agar plate-count method. II. The use of the methylene

blue reductase test at 15.5° C. as a method of determining the keeping quality of milk. *Ibid.*, **4**, 1, 105–121, 1932.
18. MADDOCK, E. C. G. : Studies on the survival time of the bovine tubercle bacillus in soil, etc., *J. Hygiene*, **33**, 1, 1933.
19. PESKETT, G. L. : Milk secretion in relation to blood composition. *J. Soc. Chem. Ind.*, **51**, 436, May 13th, 1932.

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38. HANNAH DAIRY RESEARCH INSTITUTE.

Nutrition.—Investigations are being continued into the protein requirements of dairy cattle, with special reference to the relation between the amino-acid content of foodstuffs and their value for milk production. Amino-acid analyses of a number of typical foodstuffs have been completed and are now ready for publication. The relative biological values of the proteins of certain of these foodstuffs have been determined by complete metabolic trials of milking cows. The results indicate clearly that the quality as distinct from the quantity of protein is a factor of importance in determining the relative values of different foodstuffs for milk production.

Lactation.—During the past year useful progress has been made in a study of the transport of milk precursors in the blood. The experimental technique used by previous workers had entailed the analysis of samples of blood taken simultaneously from the jugular and mammary veins, the object being to determine the differences in the composition of the blood before and after it passed through the milk glands. It appeared by no means certain that blood from the jugular vein did, in fact, represent the blood stream flowing to the gland, and in the preliminary experiments carried out at the Institute, samples of arterial blood were also examined. The results of these experiments showed that previous workers, in reaching their conclusions, had failed to take into account a number of interfering factors. Methods were therefore worked out by means of which it is possible to apply correction factors to any future results (1, 2). By the application of these factors to further experiments, it has been definitely established that milk sugar is derived from the glucose of the blood, and that the milk proteins are derived—in part at least—from the free amino-acids (3, 4). Previous conceptions as to the origin of the phosphorus in milk have also been revised (5), and it has been possible to put forward a new hypothesis of the physico-chemical mechanism which controls milk secretion (6). The results of this work indicate the value of methods of blood analysis in the investigation and solution of the problems of milk secretion.

Work is now proceeding on a further aspect of milk secretion, namely, the actual chemical transformations which lead to the

production of milk in the secreting glands. A preliminary study has been made of the process of breakdown of casein by enzymes (7).

Genetics of dairy cattle.—A study has been made of the genetic construction of the Ayrshire breed of cattle, with special reference to the degree of inbreeding of the breed (8). The coefficient of inbreeding for the whole breed worked out at about 5 per cent. High yielding cows showed a markedly lower coefficient of inbreeding than the breed average, though it appeared that inbreeding itself had no detrimental influence on milk yield. A careful examination of a very large number of pedigrees demonstrated the marked influence of one foundation herd in determining the genetic construction of the whole breed.

" Wastage " in dairy herds.—Owing to lack of financial assistance the inquiry into the causes of loss of milking cattle, referred to in the last Report, has had to be discontinued. A summary of existing information has meantime been published (9). A survey into the extent and causes of premature losses among calves has been carried out, and the results, which will shortly be published, indicate that such losses also constitute a serious source of wastage in dairy herds.

Tuberculosis in dairy cows.—The investigation into the infection of the Scottish milk supply, which has been carried out in conjunction with the Department of Health for Scotland and the Health Authorities of Edinburgh, Glasgow, Dundee and Aberdeen, has now been completed. The results indicate, *inter alia*, (a) the unsatisfactory nature of the existing milk supply, (b) the profound effect of " bulking " in increasing the percentage infection of milk, (c) the urgent need for proper control of methods of commercial pasteurisation, if this process is used for reducing infection, and (d) the outstanding value of tuberculin-tested herds as a means of safeguarding the milk supply.

In view of the last conclusion, the results obtained by the Institute in its experimental tuberculosis eradication scheme are of importance. This scheme, which is financed by the Medical Research Council, has now been in progress for three years. The only incentives given to the 32 herd owners included in the experimental area have been the provision of free tuberculin testing and of free advice on methods of isolation and on the rearing of tubercle-free young stock. Already, however, two-thirds of the herds in the area are free from the disease, while the incidence of infection in practically every other herd has been substantially reduced. In addition, a mass of data has been obtained on such points as the major sources of tuberculous infection, and the reliability of the tuberculin test. The results of this scheme have clearly demonstrated the feasibility of reducing the incidence of tuberculosis among dairy cattle by the provision of relatively small incentives to the herd owner.

The manufacture of dried milk.—In addition to the surveys of literature on the condensing and drying of milk which have been financed by the Empire Marketing Board, practical work has been continued on certain problems involved in the manufacture of dried milk. At the Royal Technical College, Glasgow, special attention has been directed towards the physical aspects of spray drying. Experiments have been completed which demonstrate that, in this process, the rapid evaporation of the atomised milk results in a cooling, rather than a heating, effect, and that this safeguards the milk from over-heating (10). At the Institute detailed experiments have been carried out to determine the factors which control the solubility of milk powders. It has been found that these factors are three-fold, i.e., temperature of heating, time of heating, and concentration of milk solids. The relative influence of these three factors has been studied, and the practical limits of heat treatment indicated (11). Work on both these aspects of milk drying is being continued.

Surveys of literature on the condensing and drying of milk. (Empire Marketing Board Grant.)

Two comprehensive reports have now been published in which existing knowledge on the scientific aspects of the condensing and drying of milk are summarised. The first report (13) deals mainly with the chemical and bacteriological aspects of the subject, and includes a discussion of the chemical and physical properties of milk in relation to manufacture, the influence of heat on the bacterial flora of milk, the scientific control of the processes of manufacture, and the chief defects to which the various products are subject. A supplementary paper (14) presents a detailed review of present knowledge on the mineral constituents and citric acid content of milk. The second report (15), which has been prepared in collaboration with the Royal Technical College, Glasgow, covers the engineering aspects of the subject. In this report the fundamentals of heat transmission and evaporation are briefly outlined, and the technical aspects of the subject are then reviewed under the general headings of condensing, roller-drying (both atmospheric and vacuum), and spray-drying.

The two reports, taken together, not only provide an exhaustive treatment of the scientific aspects of condensing and drying, but indicate both the mass of problems which await solution and the most promising methods of tackling such problems.

Titles of papers issued during the year.

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2. ———— : The absorption of milk precursors by the mammary gland. I. The Kaufmann-Magne technique. *Ibid.*, **26**, 357, 1932.
3. ———— : The absorption of milk precursors by the mammary gland. II. The relation of blood-sugar absorption to lactose secretion. *Ibid.*, **26**, 362, 1932.

4. Blackwood, J. H. : The absorption of milk precursors by the mammary gland. III. The relation of amino-acid absorption to protein synthesis. *Ibid.*, **26**, 772, 1932.
5. Blackwood, J. H., and Stirling, J. D. : The absorption of milk precursors by the mammary gland. IV. Aspects of the phosphorus metabolism of the mammary gland. *Ibid.*, **26**, 778, 1932.
6. ———— : The absorption of milk precursors by the mammary gland. V. Physico-chemical aspects of milk secretion. *Ibid.*, **26**, 1127, 1932.
7. Stirling, J. D., and Wishart, G. S. : The hydrolysis of caseinogen by pepsin and trypsin-kinase. *Ibid.*, **26**, 6, 1933.
8. Fowler. A. B. : The Ayrshire breed of cattle : A genetic study. *J. Dairy Res.*, **4**, 1, 1932.
9. Wright, N. C.: Wastage in dairy cows. *Scot. J. Agric.*, **16**, 1, 1933.
10. Scott, A. W. : The "cooling effect" of a hot air stream on a water surface. *J. Roy. Tech. Coll., Glasgow*, January, 1932.
11. Wright, N. C. : Factors affecting the solubility of milk powders. I. The effect of heat on the solubility of milk proteins. *J. Dairy Res.*, **4**, 1, 1932.
12. Morris, N., Rennie, J. B. and Morris, S. : The effect of intravenous injection of glycine on blood calcium. *Brit. J. Exp. Path.*, **13**, 132, 1932.
13. Allen, L. A. : The properties of milk in relation to the condensing and drying of whole milk, separated milk, and whey. A review of existing knowledge. *Hannah Dairy Res. Inst., Bull.* **3**, 1932
14. ———— : The mineral constituents and citric acid content of milk. *J. Dairy Res.*, **3**, 1, 1931.
15. Scott, A. W. : The engineering aspects of the condensing and drying of milk. *Hannah Dairy Res. Inst., Bull.* 4, 1932.

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39. DAIRY BACTERIOLOGY DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

The work of this Division has been practically confined to Routine work in connection with the Sale of Milk Act (N.I.) 1927.

A certain amount of work was done in connection with the standardisation of cream for the export trade. The problem was studied in the creamery and laboratory. As a result of the work it is hoped that definite recommendations can be made as to the most suitable methods to adopt for producing first-class cream.

I.

AGRICULTURAL ECONOMICS.

5767 H4

40. AGRICULTURAL ECONOMICS RESEARCH INSTITUTE, OXFORD UNIVERSITY.

The dairying industry.—Much of the work of the Institute Staff as a whole has been concerned with the dairying industry, both at home and abroad. (*a*) The most important part has been Mr. Prewett's intensive studies of the organisation of milk distribution. The work already done in this complex subject includes a survey of the methods of sale on about 3,500 farms in Derbyshire, a district selected because there is much local sale to a large industrial population, combined with a considerable volume of export for sale at a distance ; a survey of about the same number of farms in West Cornwall (7), where almost the entire production is manufactured on the farm or in factories into butter ; a survey of a sparsely populated agricultural district in Cambridgeshire, where the local demand is small ; a survey of the district comprised in Mid-Somerset, where farm cheese manufacture was, until recently, the principal means of disposal. In all these areas, where more than 12,000 farmers have been visited, conditions of sale in every variety have been found. Mr. Prewett embodied his preliminary conclusions on the reorganisation of milk distribution in a pamphlet published during the year (6), and he has given evidence recently before the Milk Reorganisation Commission, which has been set up to produce a scheme for the more orderly marketing of milk. (*b*) Another important survey is one made by Mr. Dixey and Mr. Messer of what may be termed open-air dairying. The system of milking in the field all the year round in a portable milking shed, introduced by Mr. A. Hosier on the Marlborough Downs, has received some notoriety, but very little is known of the extent to which the system is spreading, or its applicability to varying conditions. The survey disclosed that there are now about 120 milking bails in use, most of them in the southern counties, representing about 7,000 cows. A report is being prepared upon the experiences of the users. (*c*) A general survey of the dairying industry in England and Wales, in which most of the research staff of the Institute are participating, was set on foot at the beginning of the year. An historical review of the growth of the milk industry is contemplated, with some consideration of the present position of its various branches. The study was to have been completed within the year, but some of the material has been difficult to get, and the original scheme may have to be modified. The Deputy-Director is co-ordinating this work. (*d*) Under a grant from the Empire Marketing Fund, arrangements were made for surveys of dairying conditions in some of the Empire and foreign countries competing for the English market. Mr. Maxton has now edited a report based on communications from correspondents overseas for the Empire Marketing Board.

Price studies.—Price is the overriding factor in agriculture, and recently price studies and price forecasting have formed an increas-

ingly important part of the work of the Institute. Dr. Murray is responsible for it. The study of agricultural prices in general has been continued throughout the year, with special reference to live stock, and detailed work in connection with pig prices, both in this country and in Denmark, has been carried on, with a view to closer estimation, both in time and amount, of future price movements (19–22).

The agricultural atlas of England and Wales.—The completion of the maps of this atlas on a county basis was reported last year. They have since been assembled and printed at the Ordnance Survey Department, and an introduction contrasting the changes in the statistical position of agriculture between the years 1918 and 1928 has been contributed by Mr. Messer. The atlas was published just after the close of the year under review (2).

A study of successful farming.—The Deputy-Director, assisted by Mr. E. L. Jones, has completed a study of fifteen years of successful farming near Peterborough. The work is an interesting example of the flexibility of farming, opinions to the contrary notwithstanding, when undertaken not only with technical skill but with vigour and imagination.

The agricultural depression.—The study of the incidence of the agricultural depression made in the year 1928 by Messrs. Skilbeck and Messer was repeated by Mr. Messer in the year 1931, and his report thereon was published in the early part of this year. It showed the same general results, namely, that grass farming was less affected than arable farming, and that big farms dependent on wage labour were harder hit than the farms more or less dependent on family labour, but that the areas badly affected in 1928 were now worse, and that the area of depression was spreading. It can only be recorded that since this survey was made, conditions have become uniformly worse (5).

Farming costs and financial records.—Work under this head, which was started twenty years ago, has gone on under the direction of Mr. Lee, and information for the use of farmers has been extracted.

Titles of papers issued during the year.

(*a*) *BOOKS.*

1. Murray, K. A. H. (in collaboration with Viscount Astor). : *Land and Life : the economic national policy for agriculture.* Gollancz, 1932.
2. Messer, M. : *An agricultural atlas of England and Wales.* Ordnance Survey, 1932.
3. Miscellaneous papers in agricultural economics, **6**, 1930-31.

(*b*) *PAMPHLETS.*

4. Orwin, C. S. : *Progress in English farming systems. No. VI. High farming.* Clarendon Press, 1931.
5. Messer, M.: *The agricultural depression of* 1931 *: its nature and incidence. Ibid,* 1932.

6. Prewett, F. J. : *Problems of milk distribution. Ibid.*, 1932.
7. ———— : *Manufacturing milk. Ibid.*, 1932.
8. Lorrain Smith, E. : *Go east for a farm. Ibid.*, 1932.
9. Nineteenth Ann. Rep. and List of Publications. *Agric. Econ. Res. Inst., Oxford*, 1931.

(*c*) *ARTICLES AND ADDRESSES.*

10. Orwin, C. S. : Specialisation in farming. Centenary meeting, Brit. Assoc., September, 1931.
11. ———— : The scope of mechanised farming. Conf. power farming, Winchester, November 13, 1931.
12. ———— : Careers on the land in England. *J. Careers*, December, 1931.
13. ———— : The future of the countryside. *To-day and To-morrow*, December, 1931.
14. ———— : A challenge to the principle of mixed farming. *Shropshire Y.F.C. Mag.*, 1931.
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16. ———— : Agricultural economics. *Agric. Res. in* 1930, *R.A.S.E.*, 1931.
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20. ———— : A survey of the prices of pigs and feeding stuffs in England and Wales during 1931. *Pig. Breed. Ann.*, 1932–33.
21. ————: The study of prices in agricultural economics research. *Agric. Econ. Soc.*, Summer Meeting, Oxford, June, 1932.
22. ———— : Notes on prices and supplies during the first and second quarters of 1932. *Nat. Pig. Breed. Assoc. Gaz.*, May and August, 1932.
23. Prewett, F. J. : British and American marketing acts : a comparison. *Co-op. Marketing J.*, **6**, 2, March–April, 1932.
24. ———— : Milk production on arable land. *J. Min. Agric.*, **39**, 6, 1932.
25. ———— : The Agricultural Marketing Act. *Agric. Econ. Soc.*, Winter Meeting, December, 1931.
26. ———— : Relations between organised producers and consumers. *Oxford City and U. Co-op. Assoc.*, Ruskin College, June 13th, 1932.
27. ———— : Agricultural economics and the farmer. Surveyors' Inst. Ann. Meeting, Leamington, June 16th, 1932.
28. ———— : The milk marketing dilemma. Brit. Assoc. Meeting, York, September, 1932.

(*d*) *PERIODICAL.*

29. Occasional notes. **1**, 16, 17, 18 and 19.

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41. FARM ECONOMICS DEPARTMENT, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

The economic position of agriculture in Scotland.—A second report on the profitableness of certain groups of farms characteristic of the agriculture of important farming areas in Scotland was issued in April, 1932, covering the period 1929–30 (1). Pressure of work on the marketing investigations referred to below has prevented the

completion of a third report relating to the year 1930–31, for which, however, work on the data is in an advanced state. The number of farm accounts received from the agricultural colleges and used in this investigation shows an increase year by year.

Marketing of agricultural produce.—A report on the marketing of the Scottish potato crop has been completed and awaits publication. Work on the report on the marketing of live stock in Scotland is nearing completion.

Marketing of fruit in Angus and Perth.—During the year some assistance was given to Mr. James Vassie, M.A., research student at the School of Economics, Dundee, in connexion with an enquiry into the marketing of fruit in Angus and Perth.

Miscellaneous.—The economic features of the poultry industry in Scotland have formed the basis of a short study (2).

Titles of papers issued during the year.

1. Department of Agriculture for Scotland.: Second report on the profitableness of farming in Scotland, 1929-30, H.M.S.O., 1932.
2. Senior, W. H.: The position and prospects of the poultry industry in Scotland. *Scot. J. Agric.*, **15**, 4, 371, 1932.

J.

PRESERVATION
and
TRANSPORT.

42. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

Food Investigation.

During the year, investigations have been in progress on the following topics. A full account of the work will be found in the Report of the Food Investigation Board for the Year 1932.**

Low Temperature Research Station.

(In conjunction with the University of Cambridge).

Meat.—Hydration of colloids (13); physiology of muscle protein; evaporation from tissues; freezing of tissues (2, 12); changes in muscle pigments; changes in fats during storage (7); rapid freezing (8, 9); gas-storage of meat (11); storage of meat in small refrigerators (16); bacteriology (4, 5, 6).

Fruit and Vegetables.—Biochemical study of senescence in apples; changes in the nitrogen fractions of apples during cold-storage, and the effect on distribution of nitrogen of storing ground apple tissue at −20° C.; importance of small differences of temperature in cold-storage of apples; effect of (*a*) freezing, and (*b*) stock, on the vitamin C. of apples; control of superficial scald of apples; moulds responsible for wastage of apples; frost-tolerance and gas-tolerance of New Zealand apples; respiration, heat-production and gas-storage of bananas; relation of respiration of potatoes to concentration of sugars and to the accumulation of a depressant at low temperatures; storage trials with new potatoes; low temperature tolerance of summer-grown and autumn-grown hothouse tomatoes; frozen fruits and vegetables; concentration of orange juice; action of volatile substances and gases on growth of moulds (21).

Curing.—Theory of curing; dry salt curing and tank curing; storage of mild-cured bacon; gas-storage of bacon and pork (1); chemical changes in fat of bacon during storage.

Biological Engineering.—Evaporation from foodstuffs—eggs, apples, bananas; water relations in tissues—bananas, eggs (14, 17, 18); humidity equilibria in stacks of fruit—apples, bananas; preservation and germination of seeds; insulated containers.

Canning.—Corrosion of tin, of iron, of steel and of tin-plate; effect of metals used in the manufacture of plant on the colour of raspberries, strawberries and blackcurrants; cooling of cans; effect of sugar containing an inhibitor of corrosion of steel on formation of hydrogen swells and perforations.

** H.M. Stationery Office (in the press).

Ditton Laboratory.

Fruit and Vegetables.—Gas-storage of apples—Lane's Prince Albert, Annie Elizabeth, Cox's Orange Pippin, Ellison's Orange; gas-storage of tomatoes.

Biological Engineering.—Experimental hold—physical constants of hold, methods of measurement, biological constants of fruit stack, heat-transfer from cooling grids, effect of irregularities of temperature on fruit; storage of fruit in uninsulated store; leakage of heat into ships' insulated spaces; atmospheric control in ships' holds; leakage of carbon dioxide from gas stores—existing commercial stores, effect of air-circulation, permeability of paints, varnishes, etc.

Titles of papers issued during the year.

1. Callow, E. H.: Gas storage of pork and bacon. I. Preliminary experiments. *J. Soc. Chem. Ind. Lond.*, **51**, 116T, 1932.
2. Chambers, R., and Hale, H. P.: The formation of ice in protoplasm. *Proc. Roy. Soc.*, **110**, 336, 1932B.
3. Glennie, A. E.: Index to the literature of food investigation. *H.M. Stat. Off., Lond.*, **3**, 2, September, 1931, and **4**, 1, March, 1932.
4. Haines, R. B.: The formation of bacterial proteases, especially in synthetic media. *Biochem. J.*, **25**, 1851, 1931.
5. ————: The influence of temperature on the rate of growth of *Sporotrichum carnis*, from —10°C. to +30° C. *J. Exp. Biol.*, **8**, 379, 1931.
6. ————: The influence of temperature on the rate of growth of saprophytic Actinomyces. *Ibid.*, **9**, 45, 1932.
7. Lea, C. H.: A note on the changes in the fat of frozen mutton. *J. Soc. Chem. Ind. Lond.*, **50**, 409T, 1931.
8. Moran, T.: Rapid freezing. Critical rate of cooling. *Ibid.*, **51**, 16T, 1932.
9. Moran, T., and Hale, H. P.: Rapid freezing. Temperature of storage. *Ibid.*, **51**, 20T, 1932.
10. Moran, T.: Science and the meat industry. *Ibid.*, **51**, 84, 1932.
11. Moran, T., Smith, E. C., and Tomkins, R. G.: The inhibition of mould growth by carbon dioxide. *Ibid.*, **51**, 114T, 1932.
12. Moran, T.: Über das Gefrieren von Gelatinegallerten. *Kolloidzschr.*, **59**, 217, 1932.
13. ————: The hydration or combined water of gelatin. *Proc. Roy. Soc.*, **135**, 411, 1932A.
14. Needham, J., and Smith, M.: The relations between yolk and white in the hen's egg. I. Introduction. *J. Exp. Biol.*, **8**, 286, 1931.
15. Piqué, J.: Successful automatic temperature control. *Cold Stor. Prod. Rev.*, **35**, 83, 1932.
16. Smith, E. C., and Tomkins, R. G.: Spoilage of meat in cold-stores. "Stickiness" and growth of moulds investigated. *Ibid.*, **35**, 56, 1932.
17. Smith, M., and Shepherd, J.: The relations between yolk and white in the hen's egg. II. Osmotic equilibration. *J. Exp. Biol.*, **8**, 293, 1931.
18. Smith, M.: The relations between yolk and white in the hen's egg. III. Gas exchange in infertile eggs. *Ibid.*, **8**, 312, 1931.
19. Tetley, U.: The morphology and cytology of the apple fruit, with special reference to the Bramley's Seedling variety. *J. Pomol. Hort. Sci.*, **9**, 278, 1931.
20. Tomkins, R. G.: Wastage in banana transport. Wastage in the refrigerated transport of Canary bananas from South America to Europe. *Trop. Agric. Trinidad*, **8**, 255, 1931.

21. Tomkins, R. G., and Trout, S. A. : The use of ammonia and ammonium salts for the prevention of green mould in citrus. *J. Pomol. Hort. Sci.*, **9**, 257, 1931.
22. Trout, S. A. : Experiments on the storage of pears in artificial atmospheres. II. Subnormal oxygen atmospheres with and without the addition of carbon dioxide. *Ibid.*, **10**, 27, 1932.

43. FRUIT AND VEGETABLE PRESERVATION RESEARCH STATION, CAMPDEN, BRISTOL UNIVERSITY

The close connection which has existed between the Research Station and the canning industry during the rapid developments of the past six years has been fully maintained, and the increase in the number of canneries—there are now eighty-four—has resulted in much additional advisory work. The research work of the station has continued along the following lines.

Fruit and vegetable variety canning trials.—The results of the four years' trials on strawberries have been published (1), and the best known varieties and those which are at present grown on a commercial scale are described in detail under good, moderate and poor canning varieties. At the end of the article a full list is given of the results obtained from all the varieties tested during the four years.

A preliminary report (2) describing canning trials on fruits other than strawberries deals with cherries, cultivated blackberries, raspberries, blackcurrants and plums.

The canning trials on 44 varieties of peas carried out during 1931 (3), indicated that only a few of the varieties commonly grown by farmers and market gardeners are suitable for canning.

A report (4) on other kinds of vegetables covers all the varieties of stringless beans commonly canned in America, in addition to several English varieties of dwarf beans.

These tests also included five varieties of beetroots, nine of carrots, three of cauliflowers, fifteen of potatoes and three of turnips ; while celery, leeks, onions, spinach, Brussels sprouts and broad beans are also mentioned.

Pea canning.—The fresh pea is easily the most popular of canned vegetables, and as several firms were canning peas for the first time during 1932 a bulletin (7), describing the various factory processes in detail was prepared and circulated to canners. A description of the best varieties of peas for canning was included, and results of research work carried out in this country and in America on different aspects of the subject was incorporated.

Improvement in quality of canned products.—Several thousand samples of National Mark canned fruits have been examined at the Research Station since 1930, and reported upon to the Ministry of

Agriculture. An analysis of the reports indicates that the quality of English canned fruits can be improved if standardised methods of examination are applied in the canneries. Consequently a bulletin (8) has been prepared and circulated. Information concerning the general characteristics of each class of fruit as a whole is included, and methods of estimating the original weight of fruit packed and the original densities of syrups used are given.

Corrosion of cans.—In anticipation of the development of an export trade to tropical countries the various technical problems connected with this subject have been under investigation at Campden for the past four years. The chief cause of deterioration of canned fruits in hot climates is corrosion of the container. This may make itself evident before the cans are opened—the defects in such cases being known as hydrogen swells and perforations—or it may cause a bleaching or discoloration of the fruit.

Several hundreds of experiments, involving many thousands of cans, have been made at Campden on this subject, and a clearer knowledge of the difficulties has been obtained. Experiments are not easy to carry out, as every influencing factor must be isolated, but the method now used for controlling the experiments so as to test each factor separately is very satisfactory. The chief points studied during the year under review have been :— variation in the tinplate ; the use of a clincher before exhausting ; the addition of inhibitors ; the effect of various types of lacquers.

In all the experiments the cans have been stored continuously at a temperature of 95° F. Moreover, cans have been filled under controlled conditions, and sent out to Hong Kong, Malta and Nigeria, where they will be examined periodically and reported upon to the Research Station.

Pressure conditions inside the can during sterilisation.—The effect of pressure and vacuum on can seams, the relationship between pressure and sterilising temperature and the measurement of the expansion of cans at definite pressures, have been the subjects of extensive experiments in the Physics Laboratory.

Size of fruits and grading.—The relation between size and weight of gooseberries and stone fruits, and the frequency of occurrence of the various sizes have been determined statistically this year in conjunction with three canning factories. The results should be of considerable value in problems connected with grading.

Tin contamination.—Continuing an investigation of the tin content of foods packed in cans with various types of lacquer, analyses have been made of fruits packed in plain and lacquered cans stored at various temperatures. This work is still in hand.

Maturing of green peas.—A feature of importance in determining the suitability of any variety of pea for canning is the length of time which the peas will remain on the vines in the ideal condition. This

depends on the ratio of starch to sugar in the peas, and those varieties which do not change too rapidly from sugar to starch are to be preferred. Six of the principal varieties were grown at the Research Station, and samples were taken every two days during the development of peas in the pods. Useful practical information should be obtained from the results of the starch-sugar analyses, and it should be possible to detect those varieties which mature too rapidly.

Infection of canned vegetables by thermophilic bacteria.—The infection with " flat sour " organisms which occasionally occurs in canned peas has been attributed in America to the sugar used in the brine. All the chief English beet sugars have been tested for this organism, and also the other ingredients of the brine, and the shelled peas themselves. The results to date do not agree entirely with American work.

Titles of papers issued during the year.

1. Hirst, F., and Adam, W. B.: Strawberries—Variety canning trials, 1928–31. *Ann. Rep. Fruit and Vegetable Res. Sta., Campden, Glos.*, **15**, 1931.
2. ————: Other fruits—Variety canning trials, 1931. Preliminary report. *Ibid.*, **26**, 1931.
3. ————: Peas—Variety canning trials, 1931. *Ibid.*, **33**, 1931.
4. ————: Other vegetables—Variety canning trials. Preliminary report. *Ibid.*, **38**, 1931.
5. ————: The use of sugar syrups in fruit canning. *Canners' Bull.* No. 2 (Revised). *Res. Sta., Campden, Glos.*, June, 1932.
6. ————: Preliminary report on a rapid method of bottling fruits. *Misc. Pub.* No. 1. *Res. Sta., Campden, Glos.*, March, 1932.
7. ————: The canning of green peas. *Canners' Bull.* No. 5. *Res. Sta., Campden, Glos.*, June, 1932.
8. ————: Factory inspection of canned fruits. *Canners' Bull.* No. 4. *Res. Sta., Campden, Glos.*, May, 1932.

K.

AGRICULTURAL ENGINEERING

44. AGRICULTURAL ENGINEERING RESEARCH INSTITUTE, OXFORD UNIVERSITY.

Research.

Tractors.—Research work on wheel adhesion and other tractor characteristics has been temporarily held up owing to dry weather and the moving of the field station to Benson, but considerable progress has been made during the year and the special technique and apparatus for the tests has been completed and proved efficient. Preliminary results of very great importance have already been secured, and it is hoped that the eventual outcome of this work will place the design of tractors and tractor wheels on a more efficient basis. It is further hoped that this work will finally settle the vexed question of the padding of the soil by tractors—to which an important contribution was made by Mr. Wright in his paper read before the British Association—and will make possible the design of wheels for use mainly on grassland.

The Institute has acquired two Garrett Tractors, one with wheels and the other with a Johnson rubber jointed track. These tractors are both fitted with Diesel engines of different types.

A Caterpillar "Ten" has been purchased for the work on mechanisation of root crops referred to later in this Report.

Tractors have also been kindly lent by Messrs. Ford Motor Company, Limited, and the Massey-Harris Company, Limited.

Dynamometers.—Excellent progress has been made during the year in the design of the special equipment necessary for the measurement of drawbar pull and other factors. A new design of recording instrument for the purpose was shown at the Physical and Optical Societies' Exhibition in January, 1932, and has since been further improved. A combined recording and indicating instrument mounted on pneumatic tyres was specially designed for the Ministry's mole draining demonstrations, where it attracted great interest and secured comparative data of great value. A very simple and cheap instrument has been designed to indicate the drawbar pull of implements, and will presently be available to other Institutes at a very low cost. The Institute has collaborated with the War Department on problems of this nature.

Ploughing.— Work has been in progress during the year on ploughing with disc ploughs on several of the mechanised farms included in the survey. Implements for this purpose have been kindly lent to the Institute by Messrs. Ransomes, Sims and Jefferies, Limited, and Messrs. Massey-Harris Company, Limited.

Some experiments have been carried out on the action of discs on the soil, as the result of which a novel form of disc has been proposed which should make a furrow more of the type made by a mouldboard plough with, it is hoped, a marked decrease in the drawbar pull resulting from the friction caused by soil lodging

between the disc and the scraper which, in the ordinary disc plough, may amount to 30 per cent. of the total. It is to be hoped that funds will be forthcoming for the full scale development of this suggestion, which constitutes a new idea in ploughing.

A rotary tillage attachment has been purchased for one of the two Garrett tractors acquired by the Institute with which it is hoped it will be possible to carry out experiments in co-operation with Rothamsted.

Seed drills.—No further work has been carried out on this subject, with the exception of tests on a new spacing drill carried out in co-operation with the Norfolk Experimental Station, but further co-operative work with other stations is projected.

Haymaking.—A large amount of work on modern methods of haymaking has been carried out this summer at several centres, the results of which are being prepared for publication. A power-driven combine baler was purchased from the U.S.A. early in the season and was tried out on lucerne, hay and combine straw. The machine did not prove entirely successful under English conditions, and will be considerably modified before next season. The results were such as to prove that there is a definite use for a machine of this type if it can be produced in England at a reasonable cost, and that it has definite advantages on lucerne, in reducing loss of leaf, and on hay, which, contrary to expectations, can be baled at a higher moisture content than is permissible for ordinary stacking. A number of bales of varying moisture content were made with the co-operation of the School of Agriculture, Cambridge, who are keeping them under observation. Other machinery on which work was done were motor-driven, tractor, horse and combined horse and motor mowing machines ; motor hay sweeps ; power stackers ; etc. A note on this work was being prepared and will be published shortly.

Harvesting.—Work has been mainly confined to the combine harvester (2) which this Institute was originally responsible for introducing into this country, and which makes possible the production of wheat at an all-in cost of £5 per acre, as against £10–£12 with the conventional methods. There were 25 machines at work this harvest as against four in 1930 and ten in 1931, and an analysis of their work is at present in preparation.

A notable feature of this year's work was the organisation of a co-operative harvesting scheme, using two machines, carried out on a number of farms by the Institute on behalf of Magdalen College.

As the cost of equipment of this kind is beyond the resources of the average farmer, the Institute is endeavouring to encourage the use of the combine harvester, not only on a co-operative but also on a contract basis, in which case it forms a sound investment. Several machines have been running successfully on contract work

this summer, and there are grounds for hoping that many more will be so employed next harvest.

A questionnaire has been sent to every user of a combine, and the very large amount of information received is now being analysed. A note on the work of the combines in 1932 will be published in due course.

It is gratifying to note that a considerable number of machines of English manufacture have been sold and have done excellent work, and that a further number of these have already been ordered for next harvest.

Finality in combine design has not yet been reached, and it is possible that other forms of equipment and other methods of harvesting may yet be found, which will make possible economies of the same order as are produced by the combine and will, at the same time, be more suitable for smaller holdings.

Root crop cultivation.—At the request of the Ministry the Institute has begun work on the mechanisation of root crops, including sugar beet.

Arrangements have been made to do this work in co-operation with the Norfolk Agricultural Station at Sprowston. The experiment was begun rather late in the season, but the Institute was able to provide a Caterpillar "Ten," a row crop cultivator, and other implements, in time for the more important operations, and sufficient progress has already been made to justify the hope that the mechanised cultivation of sugar beet will be commercially possible. A number of points still require attention, and the attack on the problem will be continued next season.

Further experiments are being carried out in co-operation with the United Sugar Company Limited, at Bury St. Edmunds, who are providing the necessary funds and equipment, and for whom special implements are being developed.

It is hoped that it will eventually be possible to realise economies in the production of sugar beet and other root crops of the same magnitude as those which have been secured in the production of grain.

Spraying.—Work was undertaken this spring, in co-operation with the other agricultural departments of the University, on the control of charlock by spraying with dilute sulphuric acid. The experiments, which were carried out on a large scale and an entirely commercial basis on two mechanised farms, were quite remarkably successful as far as the destruction of annual weeds was concerned, and showed that this method was practically independent of weather conditions. It was noticed that the cereal crops sprayed showed a marked and quite unexpected increase of vigour which could not be ascribed to the elimination of the charlock. It was eventually found that, though there was no significant increase of nitrification, the effect of the small amount of acid was to cause a considerable increase in the amount of available phosphate in the soil, although

it is not yet clear that the increase is due to available phosphate alone. This result, which has been amply confirmed on several soils and in the laboratory, opens up an entirely new avenue in agricultural science which is being vigorously explored.

The Institute is co-operating with the leading manufacturers of spraying equipment in an attempt to produce machines suitable for use with sulphuric acid solutions in time for next spring, in view of the large number of enquiries for equipment of this type, which is not at present available in this country.

At the request of the Ministry, the Institute is taking up again work on other forms of spraying, and is co-operating with Long Ashton on fruit spraying equipment design. Considerable advances have already been made, and the co-operation of manufacturers has been promised, but, in the absence of funds for the purpose, it is feared that it will not be possible to produce any new machines this season.

Mole draining.—The Institute collaborated with the Ministry in organising four demonstrations of mole draining during the winter and spring, for which special equipment was provided. In view of the very large numbers of enquiries received every winter on this subject, a technical note, summarising all the available information, has been prepared and published (5). A few problems on the working of mole drains have still to be cleared up. Special equipment for the purpose has been constructed, and will be installed in the neighbourhood of Oxford. The Institute is anxious to encourage the practice of mole draining by contract as the possibility of obtaining contract work of this kind in many instances will justify the acquisition of a tractor by farms which could not otherwise afford one.

Grain cleaning.—It has been observed during the past harvest that a considerable improvement is still possible in the condition of grain as sent to market, whether threshed in a combine or in a stationary machine and, in addition to major problems of harvesting (including drying), special attention will be paid to this question during the harvest of 1933.

The Institute hopes to be able to extend this work to other seeds, such as grass and clover, on which its assistance has already been sought.

Electricity in agriculture.—In view of the approaching completion of the "Grid," the problems of rural electrification and its application to farming are becoming important. The Institute has undertaken an intensive study of the situation in the area round Oxford served by three large distributing companies, who have expressed their willingness to give every possible facility. The survey will include not merely the agricultural use of electricity, but of every form of power.

There is a continued demand for information on the use of windmills for generation of electricity.

Work has been continued on the use of electricity for intensive gardening both under experimental and commercial conditions, including mushroom growing in the Aylesbury district.

Poultry manure.—At the request of the Ministry, the Institute has undertaken a few experiments on the preparation of poultry guano from poultry manure. This has successfully been done at a cost within the resources of an average small farm of 1,000 birds or upwards. Further experiments are being carried out.

Live stock problems.—In view of the relative advances which have been made in other countries in the use of labour-saving and other devices in connection with stock raising, including the handling of manure, in which important economies are possible, it is proposed to include the mechanisation of this aspect of farming, on which considerable data have already been collected in the "Survey of Mechanised Farms" in the Institute's activities.

Laboratory work.—Work on the effect of drying temperatures on the germination of grain, a note on which has already been published (6) will be continued this winter. The development of a simple method of moisture testing for farmers has been completed, and will be published in due course. Work will be resumed this winter in collaboration with the Soil Science Department on the grosser mechanical properties of soils.

Testing.

The number of machines tested under the Ministry's Scheme during the year was three. Two machines were tested on behalf of the Royal Agricultural Society as entrants for the Silver Medal.

Survey of Mechanised Farms.

The survey referred to in the Report for 1931 has now been extended to include some twelve farms. Every facility has been given to the Institute by these farms and a very large number of data otherwise unobtainable have been collected for a wide range of operations.

Several experiments have been carried out by the Institute at these farms under strictly commercial conditions, and much valuable experience has been gained. It will, unfortunately, be necessary to restrict the scope of this survey in the coming year to certain specific problems, but it is hoped that it will still be possible to remain in effective touch with the more general trend of mechanised farming as exemplified in these pioneer developments.

Titles of papers issued during the year.

1. Abstracts of current literature, 1–5, 1931 and 1932.
2. Cashmore, W. H., and Newman, J. E.: Occasional notes on mechanised farming. No. 1. Combine harvesting in 1931, January, 1932.

3. Denham, H. J., Wright, S. J., and Newman, J. E. : Occasional notes on mechanised farming. No. 2. Some problems of power farming, June, 1932.
4. Bomford, D. R., Denham, H. J., Hosier, A. J., and Wright, S. J. : Increased production in agriculture. Papers read at the British Association Meeting, York, 1932. (In the press.)
5. Blackaby, J. H. : Technical notes on mechanised farming. No. 1. Mole drainage, June, 1932.
6. Cashmore, W. H. : Technical notes on mechanised farming. No. 2. Effect of heat on the germination of grain, July, 1932.
7. Newman, J. E. : Farm Mechanisation, *Agricultural Progress*, 1931.
8. ———— : Engineering developments and possibilities. Rothamsted Conference XIV. Mechanisation and British agriculture, 1932.
9. Wright, S. J. : Agricultural engineering. *Agricultural Research in* 1930, London, R.A.S.E., 1931.

II.

LOCAL INVESTIGATIONS at ADVISORY CENTRES.

L.

CHEMISTRY.

45. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

The results of the following investigations have been published :—(*a*) The chemical composition of the miscellaneous herbs of pastures (1, 3), and (*b*) the effect of manures on the nitrogen and mineral content of the produce of contrasting pasture types (2, 3).

The problems at present under investigation are :—(*a*) The mineral content of certain species of grasses grown in mixtures as compared with the same species grown in plots and drills (second year) ; (*b*) the effect of different manurial treatment on the yield and chemical composition of upland and lowland pastures (second year) ; (*c*) a comparison of the chemical composition of the produce of a cheap seed mixture (trade cleanings, containing some wild white clover) sown on the hills, with that of the natural produce of those areas ; (*d*) the determination of the total, digestible, true, amide and ammoniacal nitrogen of pasture grass cut at monthly intervals throughout the growing season ; and (*e*) a study of the principal chemical changes that take place on the conversion of grass into ensilage.

It will be realised, from the fact that this province is mainly pastoral, that the chief interest of the farmers is grassland and its management together with stock rearing. The result of this is that the work is purposely biased in this direction. Again the fact that close co-operation is maintained with the Welsh Plant Breeding Station still further emphasises this bias in the research work. This emphasis on research work relating to grassland problems is in keeping with the requirements for the conduct of advisory work in the area, and is found to be of inestimable value in that respect. Most of the enquiries received from farmers relate to soils, manures and crops, more particularly in their relation to grassland.

Titles of papers issued during the year.

1. Fagan, T. W., and Watkins, H. T. : The chemical composition of the miscellaneous herbs of pastures. *Welsh J. Agric.*, **8**, 1932.
2. ———— : The effect of manures on the nitrogen and mineral content of the produce of contrasting pasture types. *Ibid.*, **8**, 1932.
3. Fagan, T. W. : The influence of nitrogenous manures on the chemical composition of the produce of individual grasses as pasture, hay and aftermath. *Welsh Plant Breed. Sta. Bull.*, **H. 13**, 1926–1931.

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46. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

A stage in the work of the Agricultural Chemistry Department was marked by the publication of Professor Robinson's book on Soils (1), in which the results of his own studies are linked up with those of workers in all parts of the world. Naturally, Welsh soils

are largely used for purposes of illustration, but soil sent from different parts of the Empire in connection with the special investigation mentioned below are also freely discussed.

The soil survey of Wales, which is being carried out from Bangor by Messrs. D. O. Hughes and W. G. D. Walters, is now proceeding along routine lines. The position after seven years is as follows :— Flintshire has been completed, Anglesey is almost complete, large areas in Caernarvonshire, Denbighshire and Glamorganshire, and small areas in Monmouthshire, Carmarthenshire and Cardiganshire have been mapped. It is anticipated that, with the standardisation of methods, progress in future will be more rapid, particularly since the more complicated areas have been dealt with first.

Mr. McLean, from his studies of the attack of hydrogen peroxide on soil organic matter, concludes that the main constituent is a single complex whose composition is specific for a given soil.

Mr. Rice Williams has studied the exchangeable base content of carbonate soils, using a method devised by himself. From a consideration of the results obtained, taken in conjunction with their clay and organic carbon contents, he has arrived at an empirical formula for calculating the base-exchange capacity of a soil.

In collaboration with Dr. M. Richardson, a method has been worked out for determining the degree of weathering of soils.

An investigation, now completed, has been made into the mechanical analysis of soils, in collaboration with Dr. M. Richardson. The work was undertaken at the instance of the Imperial Bureau of Soil Science and was financed by the Empire Marketing Board. Over 120 soils from all parts of the Empire were examined. A report has now been issued (5).

Titles of papers issued during the year.

1. Robinson, G. W. : Soils. *Encyclopædia Sci. Agric.* Baillière, Tindal and Cox. London, 1931.
2. ———— : Soils : Their origin, constitution and classification : An introduction to pedology. 390, Thos. Murby & Co., London.
3. Robinson, G. W., and Richardson, M. : Degree of weathering of soils. *Nature*, **124**, 581–582, 1932.
4. Hughes, D. O., and Walters, W. G. : Soil survey of Wales. Progress report, 1929-1931. *Welsh J. Agric.*, **8**, 197–213, 1932.
5. Robinson, G. W., and Richardson, M. : The dispersion of soils in mechanical analysis. *Imp. Bureau Soil Sci. Tech. Com.*, 26, 1933.

47. BRISTOL UNIVERSITY.

The sugar beet investigations (1) which have been in progress for the past six years have been curtailed as they have now provided the adviser with such information as was required for advisory purposes.

Experiments to determine the usefulness of sodium chlorate in the control of weeds have been concluded. These have shown

that the chemical is effective against couch grass and creeping bent, but is almost useless in the control of docks, bindweed and other deep-rooting plants.

The grassland investigations have been modified in scope as the result of several special grants. So far as the West of England is concerned, the preliminary data obtained indicate that the herbage of many of the pastures of the West of England has a relatively high feeding value during certain of the winter months and contributes appreciably to the ration of grazing animals.

A comprehensive survey of the Teart grasslands of Somerset has been commenced in collaboration with the adviser in veterinary science, a botanist and a soil surveyor.

In view of the increasing importance of poultry, a study is being made of the effects of folding poultry on grassland on the chemical composition of the herbage.

Problems are being studied in connection with the preparation of grass silage made in the stack, with and without chemical treatment.

Striking changes have been recorded in the chemical composition of Down herbage as the result of intensive manuring and grazing for a period of 3 years.

A soil and utilisation survey of part of the Lower Greensand formation in Wiltshire occurring between Calne and Devizes has been completed and it is hoped to issue shortly a report on this survey with special reference to the development of market gardening in this area.

Titles of papers issued during the year.

1. Ling, A. W., and Muir, W. R.: Experiments on the manuring of sugar beet on acid soils. *J. Bath & West Soc.*, **6**, 33–38, 1932.
2. Ling, A. W.: Injury due to red Bartsia. *J. Min. Agric.*, **39**, 5, August, 1932.

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48. CAMBRIDGE UNIVERSITY.

Liming.—Yield data on cereals and maple peas were obtained by the sampling technique recently developed by members of the Rothamsted staff.

The experiments have been extended by the establishment during the winter of 1931-32 of two centres on black fen and one on alluvial soil devoted to market gardening.

Observations have been continued on the demonstration plots at Tunstall established in 1926 by the organiser for East Suffolk.

Dried poultry manure.—Experiments on the kiln-drying of poultry manure carried out in conjunction with the organiser for West Suffolk have been completed and a report published in the "Journal of the Ministry of Agriculture."

Manuring.

(a) *Market garden soils.*—The advisory chemist has continued to co-operate with the organisers for Bedford and Cambridge in experiments on the manuring of market garden crops.

Experiments have been carried out in co-operation with the organisers for Bedford and Cambridge into the effect of "time of application of potash" for early potatoes.

(b) *Black fen soils.*—Experiments have been commenced in conjunction with the organiser for Cambridge into the use of the cheaper types of phosphate for arable crops on these soils, and also their requirements for nitrogen and potash. The effect of applying the phosphate in a heavy dressing to one crop as opposed to spreading it out over the rotation is also being tested.

Potato sickness (eelworm).—A number of soils have been examined in connection with observations and experiments being carried out by the organiser for Bedford.

Chicory.—The recent establishment of a chicory drying factory in Huntingdonshire has resulted in a considerable acreage of this crop being grown in the district. Experiments on the manuring of this crop on gravel and fen soils are in progress in conjunction with the horticultural instructor for Huntingdonshire.

Grassland.—The cause of low milk yields on certain marsh grazing has been investigated. The trouble appears to be related to the composition of the herbage, and remedial measures in the form of manurial treatment have been tried this year and appear likely to prove successful.

Titles of papers issued during the year.

1. Hanley, F.: The production of kiln-dried poultry manure. *J. Min. Agric.*, **39**, 7, 656–663, October, 1932.
2. ————: The effect of frequent applications of sulphate of ammonia to permanent grassland in East Anglia. *Agric. Prog.*, **9**, 64–73, 1932.

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49. HARPER ADAMS AGRICULTURAL COLLEGE.

Soil survey.—The classification and mapping of an area of 90,000 acres of North Shropshire is nearly completed. The laboratory work continues and numerous profiles have been sampled and analysed during the year.

Soil acidity.—The fifth year of the quadruplicate "class A" liming experiment has been completed, with barley as crop. The striking differences of previous years were confirmed, the control plots being practically bare of crop.

Grassland experiments.—The small plot tests carried out for the Pasture Committee have now been discontinued.

A new experiment designed to give information on the manurial

requirements of grass on peat soil has shown in the first year significant improvement in hay yield for both phosphatic and potassic treatments, but no difference between the effects of superphosphate and mineral phosphate.

An experiment to compare the effects of superphosphate, basic slags (high and low grade) and mineral phosphate on hay yield on a silt loam soil (Penrhyn series) showed in the third season a marked improvement due to phosphatic treatment.

Nutritional requirements of sugar beet.—An experiment is in progress to test the validity of various methods of assessing the available phosphate and potash in the soil, with special reference to the growth of sugar beet.

Grey spot in oats and manganese deficiency.—Manuring experiments with manganese sulphate on a humus sand soil in Warwickshire have yielded promising results in relation to the control of "grey leaf spot" in oats. An application of 60 lb. per acre of manganese sulphate with the seed produced a marked reduction in the incidence of the trouble and corresponding improvement in the crop.

Title of paper issued during the year.

DAVIES, W. M., and WILSON, T. O.: The storage of sugar beet on the farm. *J. Min. Agric.*, **38**, 8, 806, 1931.

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50. LEEDS UNIVERSITY.

Ammonium bicarbonate.—Two field experiments in the form of Latin squares have been conducted at the University Farm. These were designed to test the manurial value of ammonium bicarbonate, a by-product in the distillation of coal. As a top dressing for wheat (following "seeds" hay) ammonium bicarbonate proved as efficacious as ammonium sulphate—a 6 per cent. increase in total crop. With potatoes, however, an application of bicarbonate at the rate of 3 cwt. per acre produced only a 30 per cent. increase, whereas the increase produced by the same quantity of nitrogen in the form of ammonium sulphate approached 60 per cent. Similar experiments with swedes, sugar beet, and potatoes are contemplated for next season. The effects of the two fertilisers on the reaction of the soil, and on the rate and extent of nitrification are being followed, both in pot and field experiments.

Basic slag.—The advisory chemist has assisted the Permanent Committee on Basic Slag in the conducting of two field experiments on the manuring of meadow hay. At one of these centres striking results were obtained, the increase in yield produced by superphosphate and basic slag of high solubility exceeding 50 per cent. after only 5 months, and the recovery of P_2O_5 exceeded 10 per cent.

Potatoes.—In co-operation with the lecturer in agricultural economics an investigation was carried out on the soil factors affecting the successful growth of potatoes, following similar work in previous years on sugar beet, wheat, flax, and peas.

" Carr " soils and grassland demonstrations.—Field experiments, which it was hoped to conduct on " Carr " soils and further grassland demonstrations, have been in abeyance owing to financial dificulties.

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51. MANCHESTER UNIVERSITY.

The possible relationship between incidence of potato sickness and manurial status of the soil was examined by comparison between samples taken from normal and affected areas in the same fields. The pH, citric soluble phosphoric acid, exchangeable potash, ammonium and nitrate nitrogen estimations were carried out, but no consistent relationship between any of these quantities and " sickness " was apparent.

A trial of manganese sulphate dressing as a control of grey leaf disease in oats was again inconclusive. Ash analysis of diseased plants did not show an increased calcium content although the disease usually develops after recent liming.

The composition of the foliage and fruit of tomato plants grown under controlled fertiliser treatments was investigated. The analytical results showed the dependence of the composition of the dry matter on fertiliser balance and the data obtained will be useful for comparison with those obtained in advisory work.

Further laboratory work was carried out on methods for the colorimetric estimation of phosphoric acid in soil extracts. The experimental work on the composition of the phosphatic compounds in acid soils was continued and the results are being prepared for publication.

Title of paper issued during the year.

STEWART, R.: The Mitscherlich, Wiessmann and Neubauer methods of determining the nutrient content of soils. *Tech. Com.* 25, *Imp. Bureau Soil Sci.*, 1932.

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52. MIDLAND AGRICULTURAL COLLEGE.

Molassed beet pulp enquiry.—The investigations undertaken at this centre and at the National Institute for Research in Dairying, Shinfield, during the past two years indicated that more information was required concerning the properties of betaine and allied compounds, in addition to research into methods of estimation of these substances in beet molasses and molassed pulp. During the period under review the continuation of the enquiry in this direction was made possible by the offer of the services of two chemists by the

Beet Sugar Factories' Committee. At the Midland College Mr. D. G. Tompkins, B.Sc., of the Allscott factory, worked on this problem for seven months. It is evident that betaine is the only compound of molasses which could be responsible for the production of fishy taint in milk. A satisfactory method of estimation of betaine has been worked out and the properties of this substance studied in detail. It is hoped that facilities will be forthcoming to continue this research during the coming season.

Destruction of mites in cheese.—As stated in the previous report, the discovery of an effective and suitable material for the destruction of this pest would be of great benefit to the manufacturers of Stilton cheese. Such an insecticide must be volatile, non-inflammable, non-poisonous and moreover incapable of imparting to the cheese an undesirable flavour. During the past two seasons many substances have been tried out on a small scale and the most promising one—ammonia gas—has been utilised for fumigating cheese stores on two occasions. A moderate control was obtained, but the method utilised—natural evaporation of concentrated ammonia solution (.880 ammonia) on the floor of the room—does not appear to produce a sufficiently high concentration of the gas. When a further case of " mited " cheese is reported other methods of dispersion will be tried out.

Poisoning of greenhouse plants.—An interesting case of the poisoning of plants in a greenhouse at Brigg (Lincolnshire) has formed the subject of an investigation during the past twelve months. This enquiry has been carried out in co-operation with the horticultural organiser of that area. Tests and observations indicated that the poisoning had been caused by the escape of small quantities of coal gas into a disused drain passing under the greenhouse. This drain has now been sealed up and it is hoped that observations during the coming winter will prove that the trouble has been solved.

Variation in the composition of milk.—During the past twelve months systematic daily sampling and analysis of the milk of 36 herds, purchased by a milk depot, has been carried out. The object of collecting this data is to ascertain the extent to which the milk purchased by a dairy may vary in composition and therefore in food value. The value of the milk from each farm on a complete quality basis has been ascertained month by month and these values compared with the price paid, irrespective of quality, on an ordinary contract basis. Full details of the method used in carrying out such a scheme of milk purchase, and the cost to the dairy are available. A report on this investigation is in course of preparation.

Failure of cereals in spring.—Further cases in the area of the failure or partial failure of spring corn have provided more samples for analysis, and three seasons' records are now available. This work is being continued.

Liming experiments.—A Latin square consisting of 16 plots was laid down in 1921 in a field on the Bunter sandstone formation in Notts. This season's crop—barley—showed considerable differences in crop as between the various plots. Twenty one-yard length single drill samples were cut from each plot and the yields of grain and straw obtained.

Titles of papers issued during the year.

1. Cranfield, H. T.: The importance of variation in the composition of milk. *J. Wilts Assn. Dairy Students*, **4**, 1, 1932.
2. ————: Problem of low fat content in morning's milk. *Agric. Prog.*, **9**, 1932.
3. ————: Laws and regulations for the prevention of adulteration of milk, and their relation to producer, retailer and consumer. *Milk Trade Gaz.*, **6**, 13 and 15. 1932.
4. ————: Lime and the soil. *Derbyshire Farmer*, **11**, 5, 1931.

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53. NEWCASTLE : ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

The investigation on the yield and composition of pasture grass from the Tree Field plots at Cockle Park has now been completed. This work was carried out with the assistance of Dr. F. J. Elliott, and a joint paper is now in the press.

Investigations now in progress include the following :—

(*a*) The yield and composition of pasture grass from intensively and extensively treated areas on Roundabouts Field at Cockle Park.

(*b*) The yield and composition of hay from certain of the Palace Leas plots at Cockle Park.

The above investigations are being carried out in conjunction with Mr. G. A. Hall, B.Sc. No results are yet available.

(*c*) The composition of common heather (*Calluna vulgaris*) of different ages. Material for this work has been obtained from hill land at Blanchland, Northumberland, where areas carrying heather of known age have been marked off.

The examination of preliminary samples taken at the beginning of July, 1932, has been completed, and does not indicate any marked decline in protein content or increase of fibre, in samples between 3 and 15 years of age. The mineral constituents show variations which are probably of significance. The analytical sample comprised green material of not more than two years' growth.

Further samples were taken at the end of August, 1932, and are in course of analysis. An attempt has been made to separate fractions representing one and two years' growth respectively.

It is hoped to study seasonal variation and other factors during 1933, and to extend the scope of the investigation to cover other moorland plants of economic importance.

(*d*) Small plot liming experiments are still in progress at two centres. Arrangements have been made for a large scale experiment at Houghall, Co. Durham. The layout will be a 5 by 5 Latin square with 1/40th acre plots.

(*e*) No further progress has been made with the soil survey work.

Title of paper issued during the year.

THOMAS, B., and ELLIOTT, F. J.: The effect of manurial treatment on nitrogen fixation and nitrification in certain experimental plots. *J. Soc. Chem. Ind.*, **51**, 39, 332T–336T, September 23rd, 1932.

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54. OXFORD UNIVERSITY.

The co-ordination of ground and air surveys has continued to be studied, with special reference to land utilisation. The advisory chemist received special permission to attend a course in the interpretation of air photography at the Royal Air Force School of Photography. Much valuable knowledge and experience was obtained. It appears that, by means of the stereoscopic examination of air photographs, a method could be devised which would greatly facilitate and speed up the work of reconnaissance survey.

In collaboration with Mr. G. C. Gaut, a portable conductivity instrument was built and tested in a number of profile excavations in the field. It was found to be of value in differentiating, by means of the movement of ions, between horizons which were not distinguishable to the eye. There are many difficulties to be overcome before the readings can be interpreted, owing to the effect of water content upon the readings obtained.

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55. READING UNIVERSITY.

Solids-not-fat in milk.—Investigations commenced two years ago on a herd of Friesian cows giving abnormally low solids-not-fat have been continued and extended to other herds. Although a practical solution of the problem has not yet been arrived at much information of value has been obtained.

Soil surveys.—The field work in connection with the fruit survey of an area in Berkshire has been completed. Laboratory work on the samples obtained is now proceeding.

Preliminary survey work has been conducted in the strawberry growing area in South Hants, as an adjunct to the economic survey now being carried out.

Manuring of seakale for forcing.—These experiments are being continued. Marked results on the field crops have been obtained, and the different effects on the forced crop as regards type of plant and quality have been noted.

Cultural treatment of marrow stem kale.—The results of the first year's experiments have warranted a continuation of the investigations. Differences in the food value per acre under different treatments have been found.

Lime-induced chlorosis.—Experiments on counteracting the effect of the above on certain horticultural and glasshouse crops have been successful, and attention is now being directed to the production of stocks suitable for propagation, improvement of size and colour of blooms, etc.

Miscellaneous.—Preliminary investigations have been commenced on the effect of lime on strawberries with and without the addition of artificial manures; improved methods for the destruction of moles and rats in the field; and co-operative work on the control of the strawberry weevil, and the treatment of narcissi against eelworm has been undertaken.

Titles of papers issued during the year.

1. Notes on the management, manuring and composition of some Dorset soils. *Reading, U. Bull.*, **42**, December, 1931.
2. Lesser, C. E.: Milk deficient in solids-not-fat. *J. Min. Agric.*, **39**, 4, 340–345, July, 1932.

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56. SEALE-HAYNE AGRICULTURAL COLLEGE.

Crop diseases and soil conditions.

A large number of data from soils in the area, relating to the incidence of fungoid and insect pests, confirm the view that soil conditions are a factor of prime importance and that soil treatment should be regarded as a fundamental control measure.

(*a*) *Finger and toe.*—This disease is common in many parts of Devon in non-acid soils. Superphosphate applications have a definite effect in increasing the severity of the disease. In a large majority of cases it is found only at the top end of the hill slope. Experiments have been started in conjunction with the advisory mycologist to try out the effect of hydrated lime, chlorate of lime, salt, etc., on land infested with the disease.

(*b*) *Potato eelworm.*—Damage by eelworm in potatoes is spreading to all parts of the area. All the cases examined show adverse soil conditions. In South Cornwall a contributing factor appears to be excessive alkalinity of the soil, induced by abnormally heavy dressings of a calcareous sea sand. In other areas potash shortage is a definite factor, etc. Arrangements have been made to conduct field trials involving various treatments on fields in both South Cornwall and Mid-Devon.

(*c*) *Blackleg in mangolds.*—Soil acidity, especially when combined with a low potash level of the soil, is an important contributing cause.

(*d*) *Patch disease in strawberries.*—A detailed investigation into the failure of strawberries is being carried out in co-operation with the advisory entomologist in two separate areas, *i.e.*, the Tamar valley and North Devon. The variations in nitrate content of the soil which promises to throw considerable light on the problem is being studied from samples taken periodically throughout the whole year.

(*e*) *Chocolate spot in beans, failure of violets, etc.*, are being investigated along similar lines.

(*f*) *Manuring for violets.*—The data already obtained indicate that soil conditions are important contributing factors and that these have in most cases been induced by excessively but unbalanced manuring. A number of plots at three centres have been laid down in order to study the crop requirements on three very different soil types. Samples will be taken at intervals according to the appearance and yield of the plants which remain normally for two or three years.

(*g*) *Lucerne.*—An experiment to determine the critical pH on Devonshire soils for lucerne by graduated dressings of lime has been carried out during the past year, and indicates that this figure is very different from that of other districts.

Deficiency disease of sheep on Dartmoor.—The analytical work necessary for this investigation by the advisory veterinary surgeon is being done in part by this department. This includes samples of soil and herbage on both " home " and " away " (*i.e.*, recuperative) pastures and samples of blood serum taken from the sheep at intervals.

Soil survey.—Continued progress was made in the survey of the soils in the South Devon area. The intensely complicated nature of the geology combined with the topography renders this work much more difficult than on level country, but the rate of mapping has been gradually speeded-up by increasing familiarity with the local conditions.

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57. WYE : SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Insecticides and fungicides.—Mr. H. Martin has continued to work upon the chemistry of insecticides and fungicides, and the determinations of the fungicidal properties of spray fluids, in co-operation with the advisory mycologist, have been extended to glyceride oils, synthetic solvents and a number of sulphur derivatives. Laboratory and field trials with ovicides and insecticides have been made in collaboration with the Entomological Department. The use of sulphite lye as a " spreader " has been tested in the orchard with satisfactory results and other waste industrial products have been studied in this connection.

The spraying trials against apple scab have been continued in the College plantation, Bordeaux mixture being compared with "Oil Bordeaux"; a trial with the same sprays was made in an orchard near Faversham, in this case against pear scab. Part was taken in a spraying demonstration against apple scab at West Farleigh.

Kent fruit soils survey.—The report upon the Lower Greensand soils and fruit—the joint work of Wye and East Malling—was presented to the Fruit Soils Survey Committee in July, 1932.

During the past year work has continued on the Hastings Beds in the area which lies between Wittersham in the east and Capel in the west. This area contains many orchards and plantations and in it fruit-growing is being extended. Mr. B. S. Furneaux has made a systematic study of the soils of the High Weald and has published an account of them (8). Sixteen soil series have been established and except in a few cases all the soils so far examined in the High Weald fall into one or other of these groups. The soils of the Hastings Beds have been divided into two main groups on the basis of the texture of the geological material. Further sub-division has been employed to differentiate between soils formed *in situ* and those of transported origin. The final separation into series has been upon the natural drainage of the soils. Special attention has been paid to soil water conditions, as this factor is of great importance in determining the suitability of a soil for any particular crop.

In view of the importance of potash in fruit-growing, a systematic investigation of the potash content of the soils of the High Weald has been started, using the *Aspergillus* biological method.

Titles of papers issued during the year.

1. Goodwin, W., Salmon, E. S., and Ware, W. M. The control of apple scab on Worcester Pearmain and Allington Pippin. A three years' experiment. *J. S. E. Agric. Coll.*, **30**, 28–50, July, 1932.
2. ————: The control of apple scab: Allington Pippin and Newton Wonder. *Ibid.*, **30**, 51–62, July, 1932.
3. Martin, H., and Salmon, E. S.: The fungicidal properties of certain spray-fluids—VIII. The fungicidal properties of mineral, tar and vegetable oils. *J. Agric. Sci.*, **21**, 4, 638–658, October, 1931.
4. Martin, H.: Studies upon the copper fungicides—I. The interaction of copper sulphate and calcium hydroxide. *Ann. Appl. Biol.*, **19**, 1, 98–120, February, 1932.
5. ————: The laboratory examination of fungicidal dusts and sprays. *Ibid.*, **19**, 2, 263–271, May 1932.
6. Austin, M. D., Jary, S. G., and Martin, H.: Studies on the ovicidal action of winter washes, 1931 trials. *J. S. E. Agric. Coll.*, **30**, 63–86, July, 1932.
7. Martin, H., and Salmon, E. S.: The fungicidal properties of certain spray-fluids—IX. The fungicidal properties of the products of hydrolysis of sulphur. *J. Agric. Sci.*, **22**, 3, 595–616, July, 1932.
8. Furneaux, B. S.: The soils of the High Weald of Kent. *J. S. E. Agric. Coll.*, **30**, 123–140, July, 1932.

58. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Lime requirement.—One of the most frequent requests in connection with soil advisory work is information as to the " lime requirement " of the soil, *i.e.*, the amount of lime which would be required to make the soil more or less neutral in reaction. Many methods are employed in different parts of the world to estimate this figure, the one most commonly used in this country being that devised by Hutchison and McLennan. This method, while satisfactory up to a point, suffers from serious objections, with the result that the figures obtained from soils of different absorptive capacity are not strictly comparable. A more serious difficulty is that it is impossible to give reliable advice on the liming of a soil on the single value obtained by the above method. To meet this difficulty, an electrometric titration method has therefore been adapted for the purpose, a solution of calcium hydroxide in an aqueous sugar solution being employed instead of the usual solution of lime water, which is too dilute. This method is now used almost exclusively for the routine measurements (1).

Soil acidity.—The first part of the investigation on the variation in soil acidity throughout the season and the effect of the growing plant upon the observed changes has been published (2). This work has been continued.

One of the most important observations has been the close parallelism in the effects of carbon dioxide and of the growing plant in raising the pH value of the soil. Further results on the effects of adding lime and sulphur respectively on the properties of the soil and the yield and composition of the crop have been obtained, and it is hoped to publish these results in one or two papers in due course.

Manurial requirements.—During the last few years considerable attention has been devoted, especially in Germany, to the possibility of estimating plant nutrient deficiencies in soils by means of biochemical methods. The purely chemical methods are unsatisfactory, while the plant culture methods are slow and too costly for routine purposes. A new method, somewhat intermediate in character between the purely chemical and the biological methods, depending on the rate of growth of a fungus (*Aspergillus niger*), has been worked out in Germany and used with apparent success. A critical examination of the method has been made by Dr. Smith and Mr. Coull and of the results obtained by applying it to a number of selected Scottish soils. A review of the possibilities of the method has been published (3). It is hoped that it may be possible to continue this investigation during the present year.

Agricultural lime.—In the course of an examination of a by-product from a paper works consisting of waste lime burned after

use for causticising purposes, it was shown that although the percentage of lime obtained by the official method was only about 60 per cent., yet the percentage of available calcium oxide according to other methods and by the actual neutralisation of soil acidity was about 80 per cent. The results were communicated to the Chemistry Committee of the Agricultural Education Association in a paper by Dr. Lauder and Dr. A. M. Smith (4). The chief criticism against attempting to devise a method for assessing the value of waste lime products lies in the great variety and variation in the qualities of these products. Due regard ought to be given, however, to the importance of any suitable supply of good lime in agricultural areas and any attempt to convert an unpopular waste product into a useful by-product should be encouraged by a suitable alteration in the method of valuation.

Potatoes.—The investigation on the identification of potato varieties by chemical tests has been continued. A further paper dealing with the kinetics of the reaction was communicated to the Royal Society of Edinburgh (5). In some case, it will be remembered, the tyrosinase reaction did not give entirely satisfactory results, and it appeared that its evidence would require to be supplemented by additional tests to effect a further separation of certain varieties. A solution of phenosafranin in water has proved useful and enables Arran Chief and Great Scot to be distinguished without difficulty. Attempts have also been made to make use of the formation of dyes by diazotisation of the amino-compounds present in potato tubers and coupling with the phenolic derivatives also present ; it has been difficult, so far, to control the conditions with sufficient accuracy to permit of close reproduction ; the investigation has been continued by Dr. A. M. Smith. A paper on the most recent developments of the work read by Dr. Smith and Dr. Robertson at the Summer Conference of the Agricultural Education Association in Edinburgh in July (6).

Storage of potatoes.—A short résumé of the results obtained has been published by Dr. A. M. Smith (7), in which it was suggested that the control of the moisture conditions seemed to be of great importance in the success of the method. The investigation is being continued and three experiments have been laid down in the field this autumn under conditions approximating closely to what might be practised on a commercial scale. A series of controlled laboratory experiments has also been undertaken to ascertain the value of certain measures for reducing the rate of sprouting in early varieties.

Nitrogenous top dressing of grain crops.—The experiments which have been carried out for the last three years under the direction of Dr. A. M. Smith on the effect of later dressings of nitrogenous fertilisers on the protein content and other properties of the grain have been continued on a field scale during the summer of 1932. It is hoped that the results will be available at an early date.

Composition of pastures.—The investigation by Dr. Lauder and Mr. McGillivray into the effect of nitrogenous manuring on the composition of pasture has been continued at Boghall. Detailed analyses of this summer's samples are in progress, and it is hoped that after another year's samples have been taken sufficient data will have been obtained for publication.

Composition of heather.—Although heather is an important food for sheep in many parts of Scotland, little information is available as to its composition and the effect on its nutritive value of different methods of management. Dr. Lauder, with the assistance of Mr. McGillivray and Dr. Comrie, has begun an investigation on this subject. Samples have been obtained from various areas during the growing season and detailed analyses are in progress. This investigation will extend over several years.

Composition of milk.—While much work has been done on the composition of the mixed milk of dairy herds, much less is known as to the exact composition of the milk of individual cows.

The establishment of a pedigree herd of dairy cattle (Shorthorns and Ayrshires) at the farm of the Institute of Animal Genetics (University of Edinburgh) at Shothead, Balerno, Midlothian, has provided an opportunity for an investigation to be commenced. By kind permission of the Director regular samples of milk are being sent in for detailed analysis. Dr. Lauder, Mr. McGillivray and Dr. Comrie are carrying out the analyses, and it is expected that interesting results may be obtained when the breeding experiments of the Institute are sufficiently advanced.

Titles of papers issued during the year.

1. Smith, A. M., and Coull : Soil research, **3**, 10, 1932.
2. Smith, A. M., and Robertson, I. M. : The influence of the plant upon seasonal change in soil acidity. *J. Agric. Sci.*, **21**, 822–831, 1931.
3. Smith, A. M., and Coull : Available plant food in soils. New Biochemical method of estimation. *Scott. J. Agric.*, **15**, 262–271, 1932.
4. Lauder, A., and Smith, A. M. : A criticism of the official method for the estimation of calcium oxide for agricultural purposes. *Agric. Prog.*, **10**, 172, 1933.
5. Robertson, I. M. : A study of the Tyrosinase of potato tubers. *Proc. Roy. Soc., Edin.*, **52**, 309, 1932.
6. Smith, A. M., and Robertson, I. M. : The identification of potato tubers by chemical methods. *Agric. Prog.*, **10**, 168, 1933.
7. Smith, A. M. : The storage of new potatoes. *Scott. J. Agric.*, **15**, 202–204, 1932.

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59. GLASGOW : WEST OF SCOTLAND AGRICULTURAL COLLEGE.

The Soil Survey of South Ayrshire has been completed and a report prepared for publication in the Memoirs of H.M. Geological Survey.

Additional information regarding the characteristics of the soils of South Ayrshire has been collected and summarised in the form of maps showing (*a*) the farming practice of the area, (*b*) the principal soil colours, and (*c*) the organic matter content as revealed by loss on ignition. A preliminary mineralogical analysis of the typical soils of the district has been made with a view to the determination of soil types. In association with the staff of the Macaulay Institute for Soil Research, attention is now being directed to a study of the profiles in the college area.

The county organisers and farmers throughout the area are now cognizant of the help which the examination of soil may afford and numerous enquiries have been dealt with regarding manurial and liming problems.

M.

ENTOMOLOGY.

60. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

It is understood that the work at this centre during 1931–32 has been carried out on the same lines as in 1930–31. Owing, however, to the adviser's illness no report on the work is available.

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61. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

Plant pests.—The exceptional abundance of aphid eggs on fruit trees last winter led to special attempts being made to extend the practice of winter spraying. A survey of crops made in the late summer showed that success had largely depended on this operation. A serious increase of red spider on apple trees in commercial orchards made it necessary to carry out tests on the control of this pest. Of the materials tested, a tar-oil-petroleum wash gave much the best results and almost complete control. Eelworm on potatoes was discovered in three new areas. The study of Collembola was continued and important facts regarding the conditions which lead to swarming were published.

Research on the ecology of aphides infesting potatoes was continued. This work has an important bearing on the scheme for the production of seed potatoes in North Wales. The existence of that scheme and Dr. Whitehead's researches on virus diseases make it possible to correlate variations in aphis population with observations regarding the transmission of disease.

From the evidence obtained in the last five years, it is concluded that the nature or degree of the infestation with *Myzus persicae* before the middle of July is the factor determining whether healthy stocks can be maintained. Examination at a later date may give misleading results. Special attention was given to the mode of hibernation of this species, and it was observed that apterous adults quite normally hibernated on cruciferous plants, especially cabbages and savoys, but also on swedes and turnips. Observations have been continued on factors affecting seasonal fluctuations.

Pests of stock.—Pests of farm stock demand another large part of the adviser's attention. Investigations on the sheep maggot fly have been in progress for some time and important results have been obtained. In North Wales only one species, *Lucilia sericata*, is involved. This has had four generations each year since 1928, and it has been demonstrated that the normal mode of hibernation is in the larval or prepupal stage. From the point of view of biological control, it is important to find a complete lack of parasitism in larvae obtained direct from living sheep. Every shepherd should be made aware that even small larvae which have only fed for 27 hours will develop into sexually mature imagines. An attempt

was made to exploit the apparent dislike of the flies to red colour by colouring a number of sheep in the College flock.

Owing to the need for economy, work on warble fly was much reduced, but there is ample evidence that the campaigns of previous years have had great and lasting effects. Apart from the considerable reduction in infestation, and even eradication on some farms, evidence was obtained of the very local habit of the fly. The toxicity of dry derris powder was demonstrated. The wet season of 1931 led to enquiries regarding the control of *Limnaea truncatula*. Help was given to a considerable number of beekeepers troubled with accarine disease in their stocks; this disease appears to be on the increase.

Title of paper issued during the year.

DAVIES, W. M.: Swarming of Collembola in England. *Nature*, **130**, 94, July 16th, 1932.

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62. BRISTOL UNIVERSITY.

Control of the apple sawfly.—Experiments in the 1932 season confirm the results of last year (1) in that the highest control of the pest is obtained on the variety Worcester Pearmain by the application of a nicotine wash at five–eight days after petal fall. Further data are required to ascertain the optimum period or periods of spray application on other varieties. Other washes were tested as a means of control.

Control of the loganberry and raspberry beetle.—Extensive experiments showed that derris washes provided a high control of the beetle and gave superior results to those obtained with various pyrethrum insecticides. The control was obtained by killing the larvae and the success of an insecticide depends on the duration of its toxicity after application. A new insecticide in the form of barium silicofluoride gave promising results.

Mixed summer washes.—Encouraging preliminary experiments have been made with summer washes possessing insecticidal and fungicidal properties.

Capsid bugs.—Experiments showed that a form of "lithiasis" of pears is caused by the apple and currant capsids.

Control of a tomato pest (*Scutigerella immaculata*).—This pest was satisfactorily controlled by means of thorough steam sterilisation of the infested soil. It was found essential to attract the pest into the top layers of the soil in order to obtain a good control.

Control of the chrysanthemum eelworm.—Preliminary experiments in the laboratory and the field have given encouraging results.

Cleaning of nursery stock.—The application of a kerosene-pyrethrum wash during the summer provided a good control of woolly aphis.

Control of willow beetles.—Experiments with derris dusts have been carried out. The optimum amounts of various wetters that may be added to a colloidal lead arsenate wash have been determined.

Titles of papers issued during the year.

1. Kearns, H. G. H., and Swarbrick, T. : Some observations on the control of the apple sawfly (*Hoplocampa testudinea* Klug.) *Ann. Rep. Long Ashton Res. Stan.*, 1931.
2. Walton, C. L., and Kearns, H. G. H. Carabid beetles as strawberry pests in the Cheddar Valley. *Ibid.*, 1931.

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63. CAMBRIDGE UNIVERSITY.

The control of raspberry beetle (*Byturus tomentosus*). — The increase in the canning industry has made the control of this pest of immediate importance. Experiments on its control were carried out in the Isle of Ely and in Essex, and in both cases good results were obtained by spraying with soft soap and derris ten days after full bloom and again ten days later. Soft soap and nicotine sulphate, which was tried only in the Isle of Ely, gave equally good results.

Experiments were carried out on its control on loganberries in Huntingdonshire and in Essex. In Huntingdonshire a very good control was obtained by dusting with a derris powder soon after the first flowers had opened. Two dustings gave a still better control. Soft soap and derris as used for raspberries gave a fairly good control at both centres, but not as good as with dusting.

The control of capsid bugs (*Plesiocoris rugicollis and Lygus pabulinus*) *on black currants*.—This experiment was carried out at Aldreth (Isle of Ely). This was a continuation of last year's experiment to find a home-made tar oil—mineral oil emulsion suitable for controlling capsids and aphides. Owing to the hardness of the water available great difficulty was experienced in getting a satisfactory emulsion and the experiment was abandoned.

The control of plum sawfly (*Hoplocampa flava*).—An attempt was made to control this pest by spraying with nicotine and soft soap at two different dates. Contrary to the findings of previous experiments these sprayings gave unsatisfactory results.

The control of apple scab (*Venturia inaequalis*). — This experiment was carried out near Cambridge in co-operation with the advisory mycologist, to study the prevention of primary infection. Two pre-blossom sprayings gave equally satisfactory results to three sprayings and better than one spraying.

The control of flea beetles in brassica seed-beds.—This experiment, started in 1931, was planned to be carried out at three centres in

Bedfordshire, but owing to the small amount of damage caused this year the experiment yielded no results and was abandoned for this season.

The part played by the potato eelworm in reducing the potato crop.—This experiment was carried out in Bedfordshire in co-operation with the advisory mycologist and the county organiser. The results were of a negative character with the exception that farmyard manure applied in the rows gave an increased yield.

The control of the carrot fly (*Psila rosae*).—This experiment was carried out in Hunts. in co-operation with Mr. J. E. M. Mellor of the Horticultural Research Station.

Further observations have been made in the life history of the carrot fly and the effects of crude naphthalene dressings at various dates on the second generation. The results are not yet available.

Red spider (*Oligonychus ulmi*).—Has been the most prevalent pest of the year both on apples and plums. On apples it was particularly noticeable on trees where copper compounds had been used to control scab, but in some cases it was bad where sulphur sprays had been used. The spiders were very late in hatching this year and some of the failures to control this pest with lime sulphur were attributable to its application before the spiders had hatched. This pest was variable in its distribution and no bad attack was seen on trees which had not been winter sprayed with tar oil.

Title of paper issued during the year.

PETHERBRIDGE, F. R.: The spraying of fruit trees. *Reading U. Bull.* **41**, November, 1931.

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64. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES.

Winter spraying trials.—Trials were carried out at five centres and, in conjunction with the Glamorgan Horticultural Staff, observations on trials were made at a further seven centres. Six washes were used in all, several of them at various strengths. Two of the washes tried were locally produced and two others were new to the area. The local washes gave quite promising results although not quite up to some of the standard tar distillate washes.

Potato eelworm (*Heterodera schachtii*).—Tests of drained creosote salts for the control of this pest were discontinued. A trial on a small scale of "liquid naphthalene"—naphthalene in a fine state of suspension which would readily mix with water—was made at two centres. Potato rows were watered with a dilution of the "liquid naphthalene" about five days after the tubers were planted —this being the time when the eelworms are found to emerge from the cysts and to attack the sprouting potato. At neither centre

was any appreciable difference noticeable between treated and untreated plants—both being similarly attacked by the pest. It seems clear that this chemical, at any rate at the strength used, will not rid the ground of the pest.

Greenhouse white fly.—The parasite (*Encarsia formosa*) was again successfully kept going throughout the winter at several centres, and these were used as distribution centres from which others requiring the parasite were supplied. Numerous new introductions of the parasite were made, practically all of which were successful.

Root fly control.—Several demonstrations of deterrent methods against cabbage root fly, carrot fly and onion fly were made. One trouble which has been found to arise in this connection is the plant scorching which may follow the use of an unsuitable grade of naphthalene. Some firms have supplied naphthalene insufficiently centrifuged and injury has resulted from its use. After test it was found that by mixing such naphthalene with slaked lime the material could be used safely.

Warble fly control.—Demonstrations of the derris-soft soap treatment for warbles in cattle were made at six centres and satisfactory results were obtained in each case.

Liver fluke.—Demonstrations of the method of eradicating the snail *Limnea truncatula*, the intermediate host of the sheep liver fluke were carried out at a number of centres. Where it was considered possible to eradicate the snails by treatment of the land with copper sulphate, a demonstration of the method of application was given and the areas requiring treatment defined. In other cases farmers were induced to open out existing ditches or to open furrows in wet land as a means of getting rid of surface water. Fields were indicated which should be kept clear of sheep during the autumn and winter months.

Big bud mite.—Further tests of the local blackcurrant variety considered to be highly resistant to big bud mite were made and a number of buds on the test bushes were found to have become infested.

Tomato root knot.—A solution of corrosive sublimate at a dilution of 1 in 500 was used to water the soil in a greenhouse where root knot eelworm trouble regularly develops.

At another centre the soil was similarly treated with "liquid naphthalene"—a locally produced substance in a form which readily mixes with water. There was no conclusive evidence that either application did anything to reduce the eelworm infestation, controls showing the same degree of root knot development.

Title of paper issued during the year.

THOMPSON, H. W.: The control of the watercress leaf beetle. (*Phædon cochleareæ*). *Welsh. J. Agric.*, 8, 233–236, 1932.

65. HARPER ADAMS AGRICULTURAL COLLEGE.

Control of the cabbage root fly.—The results of the 1931 field trials in this direction have been published (1), and these give definite indications of the value of corrosive sublimate solution and commercial naphthalene powder. These two chemical substances were further tested during 1932 at the same centres and the corrosive sublimate treatment again gave excellent results but the naphthalene treatment proved considerably less effective than in the 1931 trials. In view of these two years' results, it is believed that the naphthalene treatment is dependent to a marked extent on climatic conditions. In the 1932 trials comparison was also made between a single and three applications of corrosive sublimate solution. The single application failed at all centres to give an efficient control.

Carrot and onion flies.—Experiments with commercial naphthalene and other chemotropic substances were commenced in 1929 and have shown that of several brands of naphthalene a brand known as " drained creosote salts " is the most effectual in the prevention of carrot and onion fly attack. Of the other chemotropic substances tested, lawn mowings and weak solution of a tar-distillate (Mortegg) have given the most encouraging results. In the 1931 and 1932 experiments, attempts were also made to discover both the number of applications and the minimum quantity of " drained creosote salts " necessary to give satisfactory control of these two flies. The results obtained generally have been rather inconclusive, and it is now believed that the degree of control given by this chemical substance is not only dependent on weather conditions but also to a considerable extent on the nature of the soil. The whole matter is, however, receiving attention and special field experiments will be arranged during the coming season with the object of elucidating the part played by the soil.

Bionomics and life history of the carrot and onion flies.—The greater part of this work has been undertaken by advanced classes in the Central and other schools in Staffordshire. Nine centres have been selected and the data already collected are likely to prove of some considerable economic significance.

Bionomics and control of the beet pigmy beetle (Atomaria sp.).—In previous experiments highly satisfactory control of this beetle on sugar beet was obtained by immersing the seed prior to sowing in a solution of 1 part phenol and 5 parts magnesium sulphate in 100 parts of water. Extensive field experiments were carried out during 1932 with a view to obtaining further evidence as to the value of this solution. Unfortunately, however, the beetle failed to do any appreciable damage at the centres selected and no results are therefore obtainable.

Winter washes.—The washes which proved most successful in the 1930–31 trials were used and the results obtained fully confirm

those of last season. A complete account of the 1930–31 trials has already been published (3).

Titles of papers issued during the year.

1. Edwards, E. E.: Cabbage root fly and methods for its control. *J. Min. Agric.*, **38**, 12, 1230, March, 1932.
2. ————: Seventh annual report of the advisory department, Harper Adams Agricultural College, May, 1932.
3. ————: Winter spraying trials in the West Midlands. *J. Min. Agric.*, **39**, 5, 411, August, 1932.

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66. LEEDS UNIVERSITY.

Potato eelworm.—The work conducted during the present year has been largely concerned with the effect on the potato crop of the eelworm, *Heterodera schachtii*. The experiments consisted of plot trials at Cawood and smaller box trials at North Cave. Various chemical treatments have been tried and a further advance towards solving the problem seems to have been made.

The occurrence of *Heterodera schachtii* has again been noted on the roots of Tomato.

Celery fly.—Much attention has been given locally to the occurrence of the celery fly which was unusually scarce during the year. Growers were shown the advantage of treating the larvae by crushing them while still in the feeding stage in the leaf. Much interest was shown in the demonstrations.

Stem eelworm.—Attention was given to the occurrence of the stem eelworm in clover. An attack of the same eelworm in beans was examined, a study of the distribution of the worm in the tissues of the plant showing that the eelworm is not evident until the internal surface of the pith has been broken up by dissection.

Infected pastures.—A serious attack of *Myzus festucae* occurred in some of the pastures in the Barnsley area. In many of those attacked large patches of grass were completely destroyed. An invasion of *Aphidius* occurring on the aphids checked the attack to a considerable degree. "Mat" was present in the pastures and it was noticed that there was an apparent correlation between its occurrence and the spread of the aphis.

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67. MANCHESTER UNIVERSITY.

Control of apple sawfly.—Research work on the biology of the apple sawfly (1) indicated that a fair chance of control was offered at blossoming time if egg-laying females could be repelled by a suitable

dust. Four applications of a dust containing naphthalene were made at intervals of three to four days during the blossoming period, using the dust at the rate of 3 lb. for twenty trees at each application. The trees were examined a month later when the fruit had set and was swelling and sawfly infestation was at its height. It was found that whereas the untreated trees in the check plots showed 25 per cent. attacked fruits the treated trees showed only 7 per cent. infestation.

Control of wireworms under glass.—By means of wheat drilled in glasshouses heavily infested with wireworms at Warton the wireworms were assembled into well-defined areas. These areas were treated with calcium cyanide at the rate of 1 lb. per 35 yds. of wheat row. In this way over 75 per cent. of the assembled wireworms were destroyed(2).

Control of Depressaria on basket willows.—During the past year attention has been concentrated on the control of the willow moth *Depressaria conterminella*, which is responsible for a good deal of loss in willow beds. Two practical lines of attack have been followed: cutting the willows after the larvæ have hatched and destroying the overwintering eggs by burning hedge brushings and debris over the rows of willow stocks. The first method removes and starves numbers of newly hatched larvæ and promises to be an inexpensive method of control since it is an adaptation of routine practice. The second method has given good results against *Depressaria* and other pests with similar habits. It seems likely that the judicious use of these two methods will effect control in a practical and inexpensive way.

Biology of sawflies.—The studies of three species of sawflies infesting gooseberries and currants have been concluded and a paper on the subject has been published (3). A similar study of the life history of the apple sawfly has been concluded and a paper on the subject published (1). The plum sawfly is now under investigation in collaboration with the School of Agriculture, Cambridge, and a considerable amount of data has been obtained during the year.

Potato sickness.—Certain phases of this subject are still under investigation. Parallel studies have been made of (*a*) the rate of increase in potato root eelworm under continuous cropping with potatoes, and (*b*) the rate of decrease in the eelworm population in the absence of the host plant. These studies have been in progress since 1928 and the data collected indicate that, if the present rate of decrease is continued throughout the period, seven years is the period necessary to exhaust the cyst content of eelworm infested soils. This has a practical bearing on agriculture and indicates that in widening the rotation on " potato sick " soils, a period of seven years should be allowed between potato crops.

Titles of papers issued during the year.

1. Miles, H. W. : Biology of the apple sawfly, *Hoplocampa testudinea* Klug. *Ann. Appl. Biol.*, **19**, 420–431, 1932.
2. ————————: Control of wireworms under glass. *J. Min. Agric.*, **39**, 353–358, 1932.
3. ————————: Biological studies of sawflies infesting *Ribes*. *Bull. Entom. Res.*, **23**, 1–15, 1932.
4. ————————: The garden pebble moth, *Pionea forficalis L. North Western Naturalist*, **6**, 200–207, 1931.
5. ————————: The control of fruit pests by winter spraying. *J. Roy. Lancs. Agric. Soc.*, 1–16, 1932.

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68. MIDLAND AGRICULTURAL COLLEGE.

Rook census.—A repetition of the census of rooks in the Midlands completed 1928–1930 has been commenced during the year to study what change in population has taken place. Three counties, Nottinghamshire, Leicestershire and Rutland, surveyed in 1928, were re-surveyed in 1932. There has been a slight diminution in numbers in all three counties. The tentative conclusion is that our rook population is more or less stationary. The diminution is no greater than might be expected between a good and bad nesting season.

Economic pest survey.—During the year, two of the counties—Lindsey and Nottinghamshire—have been surveyed for damage to crops by the various pests. Slugs and leatherjackets have been specially abundant, but there have been no epidemics of specific pests. The average crop lost due to insects and other animal pests in Lindsey has been 7.2 per cent. On a total area of 844,607 acres surveyed, this is equivalent to a total loss of crop on 61,186 acres. In Nottinghamshire, the loss has been 6.1 per cent. or on 421,090 acres surveyed, this represents a total loss of crop on 25,729 acres.

Mites.—Some further work on cheese mites has been done in conjunction with the advisory chemist and the Head of the Dairy Department. Experiments are in progress on mites damaging seeds stored in warehouses, etc. Some seeds, especially radishes, are very subject to these attacks. Brassicae seeds are also frequently destroyed ; damage is especially severe after a wet harvest. At the present time, drying the seed to under 11 per cent. moisture content appears to be the best remedy, where it can be applied. Frequent " machining " of the seed is a temporary expedient.

Soil insects.—Laboratory and small scale experiments have been made on *Phyllopertha*, *Melolontha*, wireworms, millepedes, etc. Field trials were laid down for wireworms, millepedes, eelworms on potatoes, and carrot fly.

In the field trials on carrot fly this season, green tar oil absorbed in a fertiliser was used as the dressing. The attacks have been too slight to make it possible to draw any conclusions as to the merits of this substance as a deterrent on a field scale.

Miscellaneous pests.—Work has been done on a number of pests, *e.g.*, clearing a quarry and its surroundings of mosquitoes which caused terrible blisters on the arms of the workmen, clearing houses of cockroaches; fern eelworm control; mushroom pests, such as *Sciara ingenua*.

Titles of papers issued during the year.

1. Roebuck, A.: Two noteworthy farm pests in the Midlands during 1931, (*Pterostichus vulgaris and Phyllopertha horticola.*) *The Derbyshire Farmer*, **9**, 315, December, 1931.
2. ————: *Hemiptera—Heteroptera* in the Midlands. *Entom. Monthly Mag.*, September, 1932.

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69. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Soil insect fauna investigation.—This investigation was begun in a cultivated field, chosen conveniently near Newcastle, in December 1931, the aim being to find if there is any correlation between the insect population of the headlands and that of the cultivated fields, with special reference to insect pests of crops. Cubes of soil, each 9 in. by 9 in., from the field and the headlands were collected every month and examined in the laboratory. Three examinations of the soil were made, viz., (i) when spread out to dry, (ii) when passed through a $\frac{1}{8}$-in.-mesh sieve, (iii) when passed through a $\frac{1}{30}$-in.-mesh sieve. A record has been made of the insects found in the top and lower portions of each cube. Some have been bred out with a view to finding the species, while others have been preserved in tubes or mounted for future reference. The investigation is being continued.

Late treatment against cabbage root fly.—Corrosive sublimate treatment on an area of brassicae was found to be effective when adopted just as the plants were showing signs of wilting—treatment which might be advisable when earlier methods have been neglected.

Spraying trials against apple capsid (*Plesiocoris rugicollis*).—These trials were carried out on different varieties of apples in an orchard in Cumberland, where capsids were found to be causing much injury to leaves and fruit. As capsid damage has not been observed to be common or so serious in other parts of the Northern Province, it was decided to investigate this local infestation. The trials involved an examination of nine rows containing sixteen trees in each row, two rows being unsprayed and used as "controls."

The intensity of the attack was calculated by making counts of marked leaves and fruits on the different varieties.

Byturus tomentosus in raspberries.—A spraying trial was carried out against this beetle, the time of spraying being found to be the main factor for success.

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70. OXFORD UNIVERSITY.

Breeding of oats resistant to fritfly.—New hybridisations were carried out between the resistant varieties Summer and Spet and a number of new lines recently produced at Cambridge.

The general degree of fritfly infestation this year was very low, the standard susceptible types giving a figure of 26.7 per cent. and the standard resistant sorts 10.6 per cent. This circumstance was probably connected with the exceptionally warm weather during the period of maximum susceptibility to attack. The same fact may probably account for the relatively small difference in the incidence of the attack as between the two main types.

Of the material in the F_2 generation, the crosses between Abundance and Spet were by far the most promising. Of the F_5 material (crosses between Spet, Summer and Hede on the one hand, and Victory and Star on the other) sixty-six lines were retained. Lines derived from Hede were generally too late in maturing, and these were discarded with the exception of six, which showed very high resistance to fly attack. One hundred and seventy-one pedigree lines of the F_7 generation were grown on. The whole series of these showed an average loss of 16.9 per cent. from fly as against 29 per cent. from King and 25 per cent. from Victory.

In conjunction with the cage trial of this set, rod rows of the pedigree families were set out under ordinary field conditions at Cassington, by kind permission of Christ Church. Valuable evidence was thus obtained of their behaviour under field conditions and in comparison with a standard variety (Gartons' Victory). Examination of the data is not yet completed.

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71. READING UNIVERSITY.

Strawberry pests.—The provision of a research grant has permitted an extension of the work and the employment of an assistant stationed at the Botley Experimental Plot. Preliminary results suggest the possibility of controlling blossom weevil, *Anthonomus rubi,* by dusting. Data are also being accumulated in respect of the hot water method of treating runners for the eradication of pests.

Narcissus yellow stripe.—Attempts have been made to spread this disease by means of *Thrips tabaci.*

Bulb scale mite (*Tarsonemus approximatus, var. narcissi*).—The writer discovered this mite in narcissus in England in January, 1932. A comprehensive study of this pest is being undertaken as it is already recognised as being serious in U.S.A.

Chrysanthemum eelworm (*Aphelenchus ritzema-bosi*).—Losses due to this pest increase, and attention is being paid to the freeing of "stools" from infection prior to taking cuttings.

Flea beetles (*Phyllotreta spp.*).—Trials of various control measures are being undertaken on commercial holdings.

Stem and bulb eelworm (*Anguillulina dipsaci*).—Studies of the biology of this nematode continue on the lines indicated in previous reports, there being no developments to report during the year.

Titles of papers issued during the year.

1. Hodson, W. E. H.: Some strawberry pests. *Bull* **41**, *Reading U.*, 97–104, October, 1931.
2. ————: Narcissus pests. *Bull.* **51**, *Min. Agric.*, June, 1932.
3. ————: A comparison of the immature stages of *Eumerus tuberculatus*, Rond., and *Syritta pipiens*, Linn. (*Syrphidæ*). *Bull. Ent. Res.*, **22**, 55–58, March, 1931.
4. ————: A comparison of the larvæ of the *Eumerus Strigatus*, Fln., and *E. tuberculatus*, Rond. (*Syrphidæ*). *Ibid.*, **23**, 247–249, July, 1932.

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72. SEALE-HAYNE AGRICULTURAL COLLEGE.

Bulb eelworm (*Anguillulina dipsaci*).

(i) *Hot-water treatment of bulbs.*—Investigations on the subject of hot-water treatment and its relation to both eelworm and bulb have progressed satisfactorily. In previous work, little attention has been given to the size of bulbs undergoing hot-water treatment, in relation to the length of such treatment and the effect on the subsequent growth and behaviour of the bulbs resulting from the application of such knowledge. Briefly, the points which have been investigated are:—

(*a*) The times taken for the penetration of heat to the centre of bulbs of various sizes and varieties, for a considerable range of temperatures.

(*b*) A time and temperature curve for the killing of eelworm, at various temperatures, in hot water has been constructed as the result of careful experiments by methods specially devised for the purpose.

These experiments suggest that lower and safer temperatures than that of 110° F. previously employed may usefully be pressed into service, especially in connection with the treatment of bulbs prior to forcing.

The information obtained in the laboratory has been put into practice on a considerable number of eelworm-infested bulbs, and further information will be available shortly.

As the result of the information already available, it has been possible to reduce the length of treatment of various varieties considerably below the three-hour period normally employed, without risk of failure to control eelworm. A saving in the time required for the treatment of bulk lots of bulbs, by growers in the province, has been effected in several instances.

Much information has also been acquired on the effects of various temperatures on the larvæ of narcissus flies and on bulb mites.

(ii) *Treatment of soil infected by eelworm.*—The infection of land by eelworm in the narcissus-growing districts still presents a serious problem. A number of substances, which for various reasons give promise of some measure of success, have been subjected to trial under field conditions.

(iii) *Behaviour of eelworm under bulb forcing conditions.*—During the year several cases of damage of a curious nature to forced bulbs, particularly of the variety Soleil D'Or, were brought to the notice of the adviser. The trouble was found to have been caused by eelworm (*A. dipsaci*). The abnormal behaviour of the worms under these conditions is being studied further.

" Stripe " disease investigations on bulbs.—" Stripe " disease has increased greatly during the last year, particularly in certain valuable varieties. Since the disease may be in the nature of a virus, possibly carried by some insect vector, or similar organism, the advisory entomologist is associated with the advisory mycologist in this work.

Bulb flies (*Merodon equestris* and *Eumerus spp.*).—An experiment was carried out in the endeavour to discover a substance which would be highly attractive to the flies. The experiment gave negative results.

Violet leaf and flower aphis (*Myzus ornatus*).—This aphis was first reported during the latter half of January, 1932, in connection with a serious failure of violets on a farm in the Dawlish district. A new and undescribed species of aphid was found to be the cause of the trouble. As the result of inspection, the pest was found to be widespread in the area, and further losses were apparent. Experiments in the control of the pest were initiated at the College and in the field, with the result that suitable and efficient methods have been devised. A special leaflet on the violet aphis has been prepared.

Strawberry troubles.—While the causes of strawberry failures are, on the whole, understood for most strawberry districts, it is clear that special conditions are present in the Tamar Valley, calling for special investigation. Since it is clear that soil conditions are closely linked with damage by pests, and other factors, the work is being

carried out in close co-operation with the advisory chemist. Definite correllations have been established between soil conditions, particularly nitrogen content, and the condition of the plants and the pests present. Work on the above lines is being carried out on individual plants.

Hot-water treatment of runners has been investigated with special reference to the strawberry eelworm (*Aphelenchus fragariæ*) and the strawberry mite (*Tarsonemus fragariæ*). The work has now almost reached the stage where definite recommendations may be made to growers. The effects of hot water on other pests present on the strawberry are also being taken into consideration.

Potato "sickness" (*Heterodera schachtii*).—Potato "sickness," due to the attacks of eelworm (*Heterodera*) and other factors at present not fully understood, has been present for the last two years on allotments in the Sidmouth district. During the year fresh centres of infection have occurred in Devon and West Cornwall. A study of the conditions under which the trouble occurs, together with experiments for its control, are in progress in Devon in collaboration with the advisory chemist and the county agricultural authorities. Similar work will shortly be initiated in Cornwall.

Broccoli root fly (*Chortophila brassicæ*).—The adviser is closely associated with the Devon county authorities in their broccoli growing trials at various centres in the county, particularly with regard to control measures for broccoli root fly.

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73. WYE : SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Life history and control of the strawberry blossom weevil (*Anthonomous rubi* Herbst).—The full details of the life history of this weevil have now been worked out, in relation to cultivated strawberries (1). It has also been bred from a number of wild plants, found to be attacked in the field. Work on control methods has been done both in the laboratory and in the field. In the latter case, two arsenical dusts were used and in the laboratory the same dusts, together with pyrethrum preparations and barium silicofluoride.

Ovicidal action of various oil emulsions as winter washes.—This work has been continued on the lines of that carried out last year. A suitable laboratory technique for testing small quantities of the emulsions on the eggs of the capsid bug (*Lygus pabulinus*) in red currant twigs has been evolved. The object of these trials was to obtain information on the effect of oils of widely differing specifications, in order to ascertain whether or not ovicidal power could be correlated with any particular characteristic, *e.g.*, viscosity (4). In addition to the laboratory trials, which involved the treatment of some three thousand twigs, five large scale field trials were carried

out, three on apples and two on currants. The washes used were home prepared, from oils of known characteristics. Very encouraging results were obtained and one grower intends to use the wash commercially during the coming winter.

Some new insecticides and possible insecticide-fungicide combinations.—Two nicotine substitutes and a recently discovered plant alkaloid, anabasine, were used at various concentrations. The hop-damson aphis (*Phorodon humuli*) was used as the test insect. In the field, combinations of various contact insecticides with Bordeaux mixture were employed, with the object of obtaining information on the possibilities of evolving successful combination washes, to effect a reduction in the number of applications which now have to be made annually on fruit trees. At certain periods the critical time for applying insecticides and fungicides is very limited, notably immediately after the blossoming of apples when applications for apple fruit sawfly, apple capsid bug and apple scab fungus almost coincide. Apple fruit sawfly was chosen as the test insect, and contact insecticides, incorporated with modified Bordeaux mixtures, were employed. The washes were all applied heavily, in the usual manner of contact insecticides (3).

Pyrethrum.—Further observations relating to the experimental plot of pyrethrum have been made. Methods of cultivation, harvesting and drying, with approximate costs, and the pyrethrin content of the flowers have been dealt with in a published paper (2).

Insect and allied pests of mushrooms.—The fauna of mushroom beds has been studied in order to ascertain to what extent pests are introduced in the manure. Supplies of attacked mushrooms have been obtained and the insects and other pests bred out. It has become apparent that the most widespread trouble is due to flies of the genus *Sciara*, and work has largely centred round this group. Mushrooms have been grown in a cellar for the purpose of laboratory observations on the habits of the flies and also for testing out various insecticides for their effect on the mushrooms themselves.

Observations on certain capsid bugs.—The biology of the tarnished plant bug (*Lygus pratensis*), as it occurs on chrysanthemums, has been further studied and a description of its life history and control methods has been published (7). Further observations on the oviposition of *Calocoris norvegicus* and *Lygus pabulinus* have also been made (6).

The first occurrence on chrysanthemums of a rare aphid, *Macrosiphum tanaceticolum*, is recorded (5).

Titles of papers issued during the year.

1. Jary, S. G.: The strawberry blossom weevil (*Anthonomous rubi* Herbst). *J. S.E. Agric. Coll.*, 30, 171–182, July, 1932.
2. ———: Pyrethrum. *Ibid.*, 30, 183–185, July, 1932.

3. Austin, M. D., Jary, S. G., and Martin, H.: Some new contact insecticides and possible insecticide-fungicide combinations. *H.E.A. Yr. Bk.*, 1932.
4. ————: Studies on the ovicidal action of winter washes, 1931 trials. *J. S.E. Agric. Coll.*, 30, 63–86, July, 1932.
5. Jary, S. G.: *Macrosiphum tanaceticolum* Kalt. on chrysanthemums. *Entom. Monthly Mag.*, 280, December, 1931.
6. Austin, M. D.: The oviposition of capsid bugs in fence posts. *Gard. Chron.*, **91**, 386–387, May, 1932.
7. ————: A preliminary note on the tarnished plant bug (*Lygus pratensis* Linn.). *J. Roy. Hort. Soc.*, **57**, 312–320, September, 1932.

74. ABERDEEN: NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Acarine disease.—This infection has been found in 18 counties in Scotland, 18 in England, two in Wales, and one in N. Ireland. Frow's mixture (2 parts nitrobenzene, 2 parts petrol, 1 part safrole) for the treatment of acarine disease has proved very satisfactory in a number of cases examined by the department. The benefit of Frow's mixture lies in proper dosage when it is able to kill the mites of all stages inside the tracheæ of living bees. Strictly speaking, it does not "cure" diseased bees, but it kills the mites inside so that they do not pass on the infection to other bees. The recovery of the colony depends on good bee-keeping, which provides for the establishment of a strong colony as soon as possible after the treatment.

General entomology.—Cabbage root fly caused considerable loss to about 30 acres of turnips on two widely spearated areas at the end of last year. Owing to the uncertainty of where the fly will attack heavily, it is difficult to carry out experiments on control on a field scale. Other pests examined and reported upon within the College area include slugs, white fly, clothes moths, red spider, narcissus bulb flies, and dipterous maggots attacking chrysanthemum roots.

Titles of papers issued during the year.

1. Morison, G. D.: An *Acarapis* living externally on the honey-bee. *Bee World*, **12**, 110–111, 1931.
2. ————: A mite "Acarapis" that dwells on the back of the honey-bee. *Bee Kingdom* (*Cairo*), **3**, 6–11, 1932.
3. ————: Foul-brood in Great Britain. *Bee World*, **13**, 18–19, 1932.
4. ————: Nosema infection. *Better Bee-keeping*, **5**, 11–13, 1932.
5. ————: Observations and records for some Thysanoptera from Great Britain—VI. *Tmetothrips subapterus*, Hal. and *Platythrips tunicatus* Hal. *Entom. Monthly Mag.*, **68**, 33–37, 1932.

75. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

The chief problem of zoological interest which concerns the farmers in the region of the Lothians at present is the slug which damages potatoes. The species is chiefly *Agriolimax agrestis*, which attacks the tubers underground. By reason of its subterranean habits, it is difficult to control by direct insecticidal methods. A series of laboratory experiments was made to test the efficacy of poison baits consisting of bran or sliced potatoes flavoured with orange juice and poisoned with a number of different insecticides including Paris green, lead arsenate, sodium arsenite, calcium arsenate, sodium fluosilicate and barium carbonate. None of the baits proved attractive to the slugs and the mortality was in all cases so low as to be practically negligible. Visits were made to a few East Lothian farms to investigate the damage done by the slugs in the field.

Other enquiries had reference to damage by leather-jackets, big-bud mite, the gooseberry caterpillar, the bracken wire-worm and the chrysanthemum leaf-miner.

Research work on the horse-flies of Scotland is being carried out by the advisory officer. The study of the cleg has been almost completed and a commencement has been made on another species, *Tabanus fulvus*.

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MYCOLOGY
and
BOTANY.

76. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Control of bunt (*T. tritici*) *in wheat.*—The following results were obtained by treating a heavily contaminated sample of " bunted " wheat. The untreated sample gave 80 per cent. bunted ears, copper sulphate 16 per cent., formalin 6.3 per cent., formalin (steeped) 5.7 per cent., copper carbonate 5.1 per cent., copper sulphate (steeped) 3.9 per cent. and Ceresan 2 per cent. Ceresan besides controlling the disease also gave the best yield.

Control of clover mildew (*E. polygoni*).—Perfect control of this disease was obtained this year by spreading dusting sulphur over floors of glasshouses. This treatment did not injure the delicate floral parts of the plants which are easily damaged by a wet sulphur spray.

Seed treatment of oats.—Winter and spring varieties of oats treated with Ceresan gave better establishment and final yield than similar varieties untreated. An increase of 12 per cent. was obtained in favour of the treatment.

Control of finger and toe in brassicae.—In experiments carried out with cauliflowers, broccoli and cabbages, the best results have been obtained with 1 : 2000 mercuric chloride. Winter strength lime sulphur and .25 per cent. washing soda failed to give good control. The results obtained with these two treatments were only slightly better than in untreated or control samples.

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77. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

Diseases of swedes and turnips.—In farm crops diseases of swedes and turnips demanded considerable attention, and, in co-operation with the College Farm and the County Agricultural Education Authorities, field trials on an extensive scale were carried out. A Danish variety (Wilhelmsburger) has proved to be markedly resistant to finger and toe. Bacterial rot of swedes and turnips was worse in 1932 than in any year since 1921, and the opportunity is being taken to clear up the etiology and to study the agricultural aspects of the disease. A report on the technique of field trials with swedes is in the press.

Finger and toe in brassicae.—As part of a co-operative investigation organised by the Ministry of Agriculture, work on the control of finger and toe in brassicae by treatment with mercuric perchloride was continued. A good measure of control was secured with five varieties of cauliflower. The increase of from 70–80 per cent. in the weight of crop from treated plants was not due to the absence of disease, but rather to the much higher ratio of healthy to diseased roots.

Virus diseases of potatoes.—The adviser continued his work on virus diseases of potatoes, which for some years has formed his main line of research. Important differences between the respiration of healthy plants and those infected with leaf-roll have been observed and followed up (1). The methods employed have enabled a comparison to be made of the assimilation efficiency of healthy and affected potatoes. Linked up with this work is a study of the rate of growth of healthy and diseased plants. The results were communicated to Section K of the British Association at the York meeting.

Collaboration in the carrying out of the Seed Potato Scheme has been continued, and the scientific principles underlying the successful production of seed potatoes have been discussed in a paper (2).

Titles of papers issued during the year.

1. WHITEHEAD, T.: Respiration of healthy and leaf-roll potatoes. *Nature*, **128**, 967, December 5th, 1931.
2. WHITEHEAD, T., and CURRIE, J. F.: Virus diseases in relation to commercial seed potato production, together with a study by W. M. DAVIES, of the aphis population at certain selected farms. *Ann. Appl. Biol.*, **19**, 4, 1932.

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78. BRISTOL UNIVERSITY.

Fruit diseases

Diebacks of apple trees.—Inoculations with the associated fungus, *Cyoespora* sp., were unsuccessful on healthy trees except when the fungus was inserted in small dead areas burnt with a blow lamp. It then progressed rapidly down the branches.

Fruit Spots.—A prevalent spotting of Allington fruits, caused by *Glœosporium album*, was investigated in detail. The fungus is apparently not susceptible to sulphur. It occurs on small dead areas on the twigs and on mummied fruits.

Strawberry leaf spots and fruit rots. The leaf spot and fruit rot of "Paxtons" caused by *Septoria* (*Stagonospora*) *Fragariae* (1) was controlled to some extent by spraying the plants with Bordeaux mixture previous to flowering.

Observations are also being made on other strawberry diseases.

Vegetable diseases.—The investigations reported on last year by Ogilvie and Mulligan (2) have been continued.

Asparagus diseases.—Further trials for the control of *Rhizoctonia Crocorum* on asparagus have been laid down. Seedling asparagus plants in sterile soil have been infected with the fungus by placing infected roots round the bases of the plants. The fungus has been found on several weeds.

The roots of seedling asparagus plants have also been infected with *Zopfia rhizophila* in the same manner. This fungus is apparently common in the area, but its pathogenic importance is doubtful.

Diseases of dwarf beans.—" Halo blight," caused by *Bacterium Medicaginis var. phaseolocola*, has now been fully worked out. Further trials have indicated several useful resistant varieties.

Several *Fusaria* in addition to *F. martii var. Phaseoli* have been found to be associated with footrots of dwarf beans, and their pathogenicity is under examination.

Diseases of runner beans.—Investigations have been carried out on " halo blight " and a " wilt " caused by a *Fusarium sp.*

Diseases of Leeks.—Further trials on the control of the " white tip " disease of leeks (*Phytophthora Porri*) have indicated that in order to be effective spraying should be carried out early.

A disease resembling " white tip " caused by *Botrytis sp.*, and a rotting of the bases of the plants in well-defined areas near Evesham, associated with a *Fusarium*, have been investigated.

Lettuce diseases.—Attempts to control ring spot (*Marssonina panattoniana*) by means of copper-lime dusts were unsuccessful. Extensive variety trials are being carried out.

" Winter killing " in the area, usually associated with *Botrytis spp.*, has been the subject of variety and fungicidal trials.

Mint rust (*Puccinia Menthae*).—Further trials have confirmed the conclusion already arrived at that some control may be obtained by washing the roots prior to greenhouse planting.

Onion diseases.—*Botrytis spp.* are associated with " winter killing " of winter onions throughout the province. Fungicidal trials are being carried out. This disease was found to be most severe on highly nitrogenous soil.

Parsnip canker.—Much of the injury in the province is associated with dipterous larvae. Another type is, however, associated with a fungus (*Ascochyta sp.*) which has been proved to be pathogenic.

Diseases of peas.—" Sickness " (associated with *Fusarium spp.* and *Heterodera Schachtii*) was very prevalent in the Evesham area in 1932. The pathogenicity of the *Fusaria* is being investigated.

In pot experiments excellent control of foot rot caused by *Mycosphaerella pinodes* on plants from infected seeds has been obtained by seed treatment with " Ceresan."

A mosaic disease of peas was found to occur to an extent of about 1 per cent. in commercial samples.

Mosaics of vegetable marrow and cucumber and finger and toe in brassicae were also investigated.

Diseases of Flowers.

Aster foot rot and wilt.—This disease (caused by a *Fusarium sp.*) is widely distributed in the province. Studies of the fungus and variety resistance trials are in progress.

Freesia mosaic.—Most of the investigation of this disease is now being carried out by Dr. Woodward, of Oxford.

Black blotch of delphiniums.—The control of this disease (caused by *Bacterium Delphinii*) is being looked into at the request of local growers.

Brown canker of roses (caused by *Diaporthe umbrina*) was investigated. This was recorded from Europe for the first time (3).

Basket willow rust. (*Melampsora Amygdalinæ.*) The biology of the disease has been described (4). Extensive control trials have been carried out using a copper lime dust, and a tar oil winter wash.

Laboratory experiments on germination of the summer spores have indicated that they are not susceptible to sulphur but are susceptible to copper in high dilution.

Hop diseases.—Attempts at the transmission of certain hop diseases (nettlehead, split-leaf, etc.) by various hop insects have not yet given any positive results (5).

Titles of papers issued during the year.

1. Ogilvie, L.: Hard rot of strawberry fruits. *Ann. Rep. Long Ashton Sta.*, 188, 1931.
2. Ogilvie, L., and Mulligan, B. O.: Progress report on vegetable diseases —III. *Ibid.*, 119-132, 1931.
3. Ogilvie, L.: Brown canker of roses in England. *Trans. Brit. Myc. Soc.*, **17**, 122, 153, August, 1932.
4. ———: Notes on the rusts of basket willows and their control. *Ann. Rep. Long Ashton Res. Sta.*, 133–138, 1931.
5. ————: Observations on hop diseases in Herefordshire and Worcestershire, with suggestions for their control. *Ibid.*, 139–142, 1931.

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79. CAMBRIDGE UNIVERSITY.

Apple scab.—In co-operation with the advisory entomologist, the life history and control of the apple scab organism have been investigated. The results indicated that there was a definite correlation between rainfall and the intensity of apple scab. The critical months were April, May and June. If in these months the rainfall was much above normal, the intensity of scab was above normal. Spore trapping experiments indicated that the initial infection in the spring resulted from conidial spores and not ascospores. Experiments indicated that these conidia were splashed during rainstorms from pustules on the one-year-old leader and spur wood. The results of this investigation have been compiled and circulated to the horticultural organisers in the East Anglian Province.

An investigation has been made, in co-operation with the advisory entomologist and his assistant, on "Injury to apple buds by the application of winter washes." The results have been written up in book form and are to be circulated to those interested.

Helminthosporium diseases of oats and barley and their control These investigations have been continued. Satisfactory control has been established by the use of mercuric dusts.

Investigations on the dusting method of treating seed grain have been continued.

Diseases of roses.—Investigations of some rose diseases have been carried out in co-operation with Dr. Deacon of Brundall, Norfolk.

Action of light on disease organisms.—The action of visible and invisible light on disease organisms is being studied.

Titles of papers issued during the year.

1. Dillon Weston, W.A.R.: Virulency of *Tilletia caries* on wheat varieties. *Nature*, **127**, 483, 1931.
2. ———: Effect of light on urediniospores of black stem rust of wheat. *Nature*, **128**, 67, 1931.
3. ———: The relative resistance of some wheat varieties to *Tilletia caries* (D.C.) Tul. (=*T. Tritici* (Bjerk) Wint.). *Ann. Appl. Biol.*, **19**, 35, 1932.
4. ———: The effect of ultra-violet radiation on the urediniospores of some physiologic forms of *Puccinia Graminis Tritici*. *Sci. Agric.*, **12**, 81, 1931.
5. ———: Studies on the reaction of disease organisms to light. III. The reaction of disease organisms to certain wave-lengths in the visible and invisible spectrum. *Ibid.*, **12**, 352, 1932.
6. ———: Studies on the reaction of disease organisms to light. IV. The reaction of disease organisms to certain wave-lengths in the visible and invisible spectrum. *Phytopath. Z.*, **4**, 229, 1932.

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80. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES.

Sainfoin.—Most of the investigations concern sainfoin. Many of the observations already in hand concerning the permanency of the different lots have been continued. During this session much attention has been paid to vegetative propagation so as to obtain pure line plants for possible crossing. Cuttings and layers were used. Contrary to the experience of workers with red clover, more success has been obtained with spring cuttings. In addition, seed was saved from selected parent plants of old local strains.

The experiments on the effect and value of milling sainfoin seed have been terminated and the results are being written up (1).

Lucerne.—Persistence and hardiness observations on various strains were continued.

Grasses.—Pedigree strains of the chief grasses from the Welsh Plant Breeding Station have been under observation for agronomic and pathological comparison with some commercial strains.

Grassland.—(*a*) An attempt to establish wild white clover and perennial ryegrass on upland ground infested with bracken was

made. The harrowing appeared to have been too light and the cutting of the bracken too late. Only a few very weak plants of white clover and less ryegrass were found in small isolated patches where the soil had been made bare.

(*b*) Botanical analysis of manuring of hay plots at Usk has been continued.

Yellow and brown rusts of wheat.—In co-operation with other advisory centres and initiated by Mr. F. T. Brooks, observations on the incidence of the above rusts on four autumn varieties and two spring varieties were carried out at the Green Farm.

Wilhelmina and Red Marvel were the most severely attacked with the yellow rust whilst Joss and April Bearded were free. This experiment is expected to give information as to which physiological forms of these rusts occur in this district, which will be further studied at Cambridge.

Use of corrosive sublimate against clubroot.—This has been the chief field operation during the summer of 1932. There were six centres in Glamorgan and six in Monmouthshire. The experiment was conducted on lines adopted in co-operation with other advisers to test the efficacy of corrosive sublimate solution at a strength of one part in 2,000. Cauliflower was selected for test as being very subject to the disease.

The method involved two stages :—

(i) Treatment of seed bed.—1 pint per 5 ft. of drill being applied to the drill before sowing, and double the quantity between the drills when the plants were about 2 in. high.

(ii) Filling the holes with the solution (about $\frac{1}{2}$ pint per plant) before planting out.

The seed bed treatment showed some advantage, although in two Monmouthshire centres severe slug attacks interfered with the experiment. The attacks were, however, less severe on the treated drills. The planting out treatment gave beneficial results in all the Monmouthshire centres but, owing to absence of clubroot and the small number of control plants in others, the Glamorgan centres did not show a definite advantage except at one market garden. On the whole it appeared that more solution might have been employed or another application. There was no harmful effect noticed in any case, so that this strength can be safely employed.

Soya beans.—Two varieties were grown for observation, and seeds were saved from both.

Titles of papers issued during the year.

1. Rees J. : In quest of the best sainfoin. *Welsh J. Agric.*, **8**, 1932.
2. Rees, J., and Smith, A. : A rare rust on fuchsia. *Trans. Brit. Myc. Soc.*, **14**, 308, 1930.

3. Rees, J.: Summary of reports in the *Western Mail and Agricultural Supplement*, 1932.
4. ———: Mynydd-dir Cader Idris. (A review of a paper in the Journal of Ecology, by E. P. Evans.) *Brython*, May, 1932. (Welsh.)

81. HARPER ADAMS AGRICULTURAL COLLEGE.

Control of finger and toe disease.—The value of treatment with 0.05 per cent. solution of mercuric chloride for control of finger and toe disease of brassicae was further confirmed by tests at seven centres in Staffordshire. Despite a very marked improvement in the proportion of marketable heads, many roots on the treated plots in heavily infected soil continued to be infected, though less severely than on the control plots.

The treatment has also been the subject of a co-operative test in eight different provinces.

In tests with spring dressings of hydrated lime, ranging from 20 cwts. to 60 cwts. per acre, marked improvements were obtained on turnips. In similar tests with cabbage the control of clubbing was less complete.

Preliminary tests with mercuric oxide gave indications of benefit that are being further investigated.

Aster wilt.—Experiments have been started to explore practicable methods of controlling the wilt disease of Michaelmas daisies, due to *Verticillium Vilmorinii*, which occasions much loss to growers in the province.

Rusts on wheat.—In co-operation with Mr. F. T. Brooks, of the University of Cambridge, observations were made upon the incidence of yellow and brown rusts on six varieties of wheat.

Comparison of Welsh and Scotch potato stocks.—Two stocks of seed potatoes of Welsh and Scottish origin respectively were compared and records made relative to the incidence of virus diseases, and also of the weight and grade of the crops obtained. This work was carried out in collaboration with Dr. Whitehead, of University College, Bangor.

Laboratory work.—The investigations upon the fungi responsible for the leaf spot of turnips and for certain forms of rose canker have been continued as far as time permitted. It has generally been impossible to devote much continuous time to this particular work, however, and no noteworthy advance has been made this year. The persistent sterility of the former organism, under very varied conditions, still proves a serious obstacle to any satisfactory comparison of the various forms now under observation.

82. LEEDS UNIVERSITY.

Grey leaf of oats.—A report of the experiments to date is to be published shortly. In view of the failure of dressings of manganese salts (when applied in quantities which are practically economic) to eradicate the disease in Yorkshire, a further series of experiments was laid down this year in which the reputed value of applications of nitrogenous salts as a means for growing the plants out of the disease has been tested.

Potato sickness.—(In collaboration with the adviser in entomology). Soil disinfectants are being tried with the object of finding a means of stamping out the disease when it first occurs (as it often does) in small patches.

Finger and toe disease.—Experiments with water culture solutions are being continued with the object of ascertaining whether a change in the basic ratio affects the infectivity of the slime fungus—i.e., to ascertain if and why lime acts as a deterrent in this respect. Some selection of strains of swedes which appeared to be resistant to finger and toe is also in progress.

Titles of papers issued during the year.

1. Turner, D. M.: Leaf spot of oats. *Agric. Prog.*, **8**, 131–132, 1931.
2. Turner, D. M., and Millard, W. A.: Leaf spot of oats, *Helminthosporium Avenæ* (Bri. and Cav.) Eid. *Ann. Appl. Biol.*, **18**, 4, 535–558, 1931.
3. Burr, S.: Sprain or internal rust spot of potatoes (*B. rube faciens*). *Ibid.*, **18**, 4, 521–523, 1931.
4. Millard, W. A., Burr, S., and Johnson, L. R. Potato sickness. *Gard. Chron.*, **91**, 2,350, 28–29, 1932.

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83. MANCHESTER UNIVERSITY.

Clubroot of brassicae (*Plasmodiophora brassicae*).—To determine whether the corrosive sublimate method of control was of universal application, co-operative trials were carried out in 1932 along with seven other advisory mycologists. The results in the North-Western province have again proved extremely satisfactory in every way and growers are practising the method with equally satisfactory results.

Celery blight (*Septoria apii*).—Seed and soil treatment with formaldehyde has been practised by growers on an extensive scale throughout the area, following upon the previous years' highly successful and remunerative trials. The raising of clean seed stocks by one large firm has also been in progress for a year and promises well.

Tomato mildew (*Cladosporium fulvum*).—Carefully conducted trials with salicylanilide have proved this to be a very effective

controlling agent. The approximate times of application and cost per 100 plants, have been dertemined (1).

Lettuce mildew (*Bremia lactucae*).—Two continental indoor varieties have again proved absolutely immune and are being widely grown. Resistant strains of other varieties have been separated out. Proper control of this disease under glass appears to be intimately bound up with cultural and manurial treatments.

Lettuce canker (*Botrytis cinerea*).—Faulty and unbalanced manuring seems to play an important part in predisposing plants to this disease. A comprehensive series of manurial experiments to settle this point have been laid down.

Apple mildew (*Podosphaera leucotricha*).—Partial and indirect control by means of potash manuring continues to give promise of success at one centre. Direct control by means of chemical fungicides is also being compared. A combination of the two treatments seems to offer the largest measure of success.

Seed-borne cereal diseases (*Helminthosporium spp.; Tilletia spp.;* etc.).—Tests with a new British-made mercurial dressing have shown this to be much superior to a foreign article of similar composition. Both seedsmen and farmers are convinced of its value and are adopting it in practice on a large scale. Besides checking disease it indirectly stimulates germination and so allows of a lower seed rate being employed. An increase in the quality and yield of grain has also resulted.

Seed-borne root crop diseases (*Phoma lingam; Phoma betae,;* etc.). —Various chemical specifics are being tested out experimentally for the control of these destructive diseases, which, incidentally, have been extremely prevalent during the past two seasons.

Title of paper issued during the year.

1. Smith Holmes, E. : Tomato mildew control. *Gard. Chron.*, **93**, No. 4804.

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84. MIDLAND AGRICULTURAL COLLEGE.

Finger and toe in cauliflowers.—Experiments have been carried out on the control of this disease with the mercuric chloride treatment on about ¼ acre of land which bore a badly diseased crop of cauliflowers in the previous year.

The plants were raised in the open on infected land. There was a very severe attack of finger and toe in the untreated rows. In the treated rows a few plants were badly clubbed, but the rest were clean or showed only slight infection.

At the end of the season, all plants in the treated plots yielded marketable heads weighing about 1½ lb. each. The yield of cauliflowers from the untreated plots was negligible.

In a plot where no treatment was given at the time the plants were set out, a severe attack of the disease occurred and no cauliflowers were harvested. This shows the extreme importance of watering the plants with the mercuric chloride solution at the time they are planted out.

The results showed that this treatment enables cauliflowers to be grown fairly successfully on badly infected land.

Oats and barley. Leaf spot (*Helminthosporium sp.*) *and foot rot* (*Fusarium sp.*).—Experiments were carried out on the treatment of seed with a proprietary organic mercurial powder for the prevention of the above diseases. In the barley plots, no noticeable difference was found between the treated and untreated plots. In oats, the braird produced by the treated seed was much thicker, more regular, and looked stronger than that from the untreated seed. There were more cases of leaf spot (*H. Avenae*) on the control plot, but this disease was relatively unimportant. Foot rot (*Fusarium sp.*) was more important and the organic mercurial powder seemed to control this disease very effectively.

Tomato foot rot (*Phytophthora sp.*).—The experiments on the control of this disease by partial sterilisation of the soil with 2 per cent. formalin or heat were continued and again gave good results.

Mint rust (*Puccinia menthae*).—An attempt in two different localities to establish a mint bed free from rust by taking cuttings from a diseased bed in early spring gave healthy plants in the first year. In the second year the rust appeared again. It seems likely that the mycelium of *P. Menthae* must permeate the whole plant, even to the quickly growing young shoots in early spring.

Titles of papers issued during the year.

1. Stirrup, H. H.: The cost of controlling plant diseases. *The Derbyshire Farmer*, **12**, 1, Jan., 1932.
2. ———: Cutting seed potatoes. *Farmer and Stockbreeder*, **46**, 355, Feb. 15th, 1932.
3. ———: *Sclerotium rhizodes* Auersw. in England. *Trans. Brit. Myc. Soc.*, **16**, 4, 308, May, 1932.

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85. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Fusarium disease of cereals.

(*a*) *Fusarium nivale* (*Fr.*) *Ces.* (*?*) *Calonectria graminicolae* (*Berk. et. Br.*) *Wr.*—This fungus, isolated at intervals since 1926 from oats, barley, golf and bowling greens in various parts of the North of England, has been studied in comparison with the Continental strain of the same organism. On the Continent this fungus, termed "snow-mould," is one of the most serious parasites of cereals. In Britain it is a reputed cause of dead patches in turf of

lawns and greens. The principal facts deduced from the investigation were as follows :—

(i) The Continental strain of *F. nivale* differs from the British strain morphologically and physiologically.

(ii) The Continental strain is reported to thrive and do damage to crops in alkaline soils. The British strain thrives in soils of acid and alkaline reactions within, and even beyond, the limits occurring naturally in cultivated land.

(iii) The parasitic capacity of the British strain does not vary according to the reaction of the soil in which it exists.

(iv) The British strain is a serious parasite only under conditions unfavourable to the growth of cereal plants. The fungus thrives best in summer, but does most harm during winter when plant growth is suspended.

(v) The fungus causes distinct " blighting " of ears of barley, and to less extent of wheat in cool and sunless weather. So far as barley is concerned, infected grains do not give rise to infected plants if sown and grown under good conditions.

The turf problem and life-cycle of the fungus are under investigation.

(*b*) *Gibberella Saubinetii* (*Mont.*) *Sacc. Its natural occurrence.*— Two papers dealing with the Fusarium stage (*F. graminearum Schwab.*) and the perithecial stage obtained under artificial conditions, have previously been published (*Ann. Appl. Biol.*, **17, 18**). The perithecial stage was found occurring naturally (the first time recorded in Britain) on wheat ears at Cockle Park, Northumberland. The meteorological conditions for season 1932 were compared and contrasted with those of 1929, when artificially inoculated wheat and barley did not bear a perithecial stage. Its development is dependent upon a sufficiently high average temperature together with occasional exceptionally high temperatures in " heat wave " periods. Atmospheric humidity (of which no records are available for the station) suffices in areas near the coast (six miles in this instance) even in warm and dry summers. The data are represented graphically, and notes on cultures from ascospores appended in the coming issue of the Annals of Applied Biology.

Incidence of rust (*Puccinia glamarum*) *in six varieties of wheat.*— Observations on winter and spring wheats were carried out at Cockle Park Demonstration Farm in collaboration with Mr. F. T. Brooks, of the Botany School, Cambridge, who is studying the reaction of biological forms under different regional conditions. The trial is to be repeated.

Spraying for control of apple scab.—A trial was carried out on ten varieties of fruit trees at the Cumberland and Westmorland Farm School, Newton Rigg, by the horticultural instructor. For each

variety Bordeaux, lime-sulphur, proprietary substances, and copper dust sprays were used. The wet sprays gave excellent results; the dry dusting and three proprietary wet sprays were useless.

White blotch of leeks (*Phytophthora Porri*).—The preliminary trials of control measures made in 1931 were repeated in 1932. These proved abortive owing to the exceptionally dry summer, no significant data being obtained.

Title of paper issued during the year.

1. Bennett, F. T.: *Fusarium* species on British cereals. The *Gibbosum* group: *F. scirpi* Lamb et Fautr. *Ann. Appl. Biol.*, **19**, 21–34, Feb., 1932.

86. OXFORD UNIVERSITY.

Apple mildew.—The work on apple mildew has been continued with the aid of a special grant. Further evidence has been obtained on the efficiency of control by sulphur-casein, which substance has the important advantage, over other forms of sulphur, that it produces a negligible amount of scorching of the leaves. There seems to be every hope that, after one further season's work, it will be possible to draw up practical recommendations for the grower.

Miscellaneous.—Further evidence has been secured confirming the virus nature of the disease of freesias mentioned in previous reports.

The work on *Cercospora fabae*, and other diseases resembling "chocolate spot" in beans, has been concluded meanwhile, and the results published (1).

Title of paper issued during the year.

1. Woodward, R. C.: *Cercospora fabae* Fautrey, on field beans. *Trans. Brit. Myc. Soc.*, **17**, 3, 195–202, Nov., 1932.

87. READING UNIVERSITY.

Phytophthora diseases of tulips.—It has now been decided, with the co-operation of Mr. S. F. Ashby of the Imperial Mycological Institute, that the pathogen with which most of the work has been carried out during the last two seasons is actually *Phytophthora erythroseptica*. Authentic cultures of *Phyt. Richardiae* have not yet proved to be pathogenic. *Phyt. cryptogea*, previously associated with one of the phases of the disease at other centres, although it had not been shown to be the cause of that phase, has been isolated from diseased plants on commercial nurseries. The full extent of its activities is being worked out for comparison with the *Phyt. erythroseptica* disease. There appears to be little chance of infection with the latter fungus being carried over on carefully sorted bulbs. Wm. Pitt and Wm. Copeland are susceptible varieties. Pride of

Haarlem, Clara Butt and Inglescombe Yellow showed little susceptibility outdoors to *Phyt. erythroseptica*.

Bunt in wheat.—" Spore load " trials have been carried out with the variety White Victor for comparison with previous results with Little Joss.

With three varieties a mixture of paraformaldehyde and talc considerably reduced the amount of bunt developing in the crop, but the degree of control was very unsatisfactory when compared with Ceresan (European) and copper carbonate dust.

Finger-and-toe in brassicae.—Trials in Hampshire, directly under the control of Mr. Ibbett, have brought to the notice of many small growers the usefulness of mercuric chloride for obtaining a stock of clean seedlings, but have also emphasised the antipathy to using such a dangerous poison in many cases. Calcium cyanamide had little effect on bad cases of " club," but calcium carbide waste, obtainable locally cheaply, was useful.

Botrytis disease of lettuce.—Trials by a large Middlesex grower, suggested by Prof. Brown of the Imperial College, showed that dipping lettuce seedlings at the time of planting out in Uspulun solution considerably reduces the subsequent losses through Botrytis in the field, but the method of treatment is not good enough to recommend to the ordinary grower.

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88. SEALE-HAYNE AGRICULTURAL COLLEGE.

Potato blight.—Detailed observations were made of the weather (especially relative humidity) in relation to the appearance and progress of potato blight. The important influence of humidity and the practicability of forecasting the appearance of the disease were again demonstrated.

The progress of the disease was recorded in detail in different plots in order to obtain more information about the methods of disease measurement employed in this and previous experiments.

Control of black leg of mangolds.—A small number of disinfection experiments, liming trials and soil analyses were made and agreed with previous work, but the extreme scarcity of the disease prevented any fresh information being obtained.

Narcissus diseases.—Experiments and observations have been continued on *Ramularia vallisumbrosae*, *Stagonospora curtisii*, *Botrytis narcissicola* and yellow stripe.

Hot water treatment of narcissus bulbs.—Data have been collected on the effects of the standard hot water treatment of narcissus bulbs on flowering and on the incidence of fungal diseases on a larger scale than last year.

Iris leaf spot (*Heterosporium gracile*).—The experiments laid down gave no results as the disease did not appear.

Finger-and-toe and soil treatment.—Much information has been collected on the constitution of soils where the disease occurs, and field experiments have been arranged in which different minerals were applied and their effects on the disease and on the soil observed. The extreme efficiency of hydrated lime has been demonstrated, but cheaper substances have been tried, which might give an economic control though less efficient than lime.

Titles of papers issued during the year.

1. Beaumont, A., Hodson, W. E. H., and Staniland, L. N.: Eighth annual report, Department of Plant Pathology, year ended September, 30th, 1931. *Seale-Hayne Coll. Pamph.*, **37**, Newton Abbott, 1932.
2. Beaumont, A.: The relation of weather to the appearance and progress of potato blight. *Rep. Agric. Met. Conf.*, 1931, 12–17.

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89. WYE : SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Downy mildew of the hop (*Pseudoperonospora humuli*).—The attacks of downy mildew were so severe in the earlier parts of the season that the services of the Department were constantly requisitioned for advice as to how to deal with the removal of the disease and obtain sufficient bine to grow the crop. Where intelligent spraying was carried out on the lines laid down by Wye College—and it was estimated that in Kent over eighty per cent. of hop growers sprayed the crop—the disease was combated with complete success and crops of hops entirely free from downy mildew were secured. The fight against the disease was helped very materially by the hot, dry summer. Investigations made on the farm and in the laboratory showed that losses were suffered in hop gardens during the winter of 1931–1932 through the downy mildew attacking and killing the rootstocks ("hills").

Virus diseases of the hop.—Mosaic disease.—A large number of different varieties of hops were grafted, in order to obtain information as to which of these were "carriers." Experiments were concluded showing that in all probability this disease is not transmitted through the soil.

Chlorotic disease.—Experiments were carried out with (symptomless) mosaic-carriers to which chlorotic disease had been transmitted by grafting or budding. It was found that the carriers may show eventually marked symptoms of mosaic disease. A study of various weeds (commonly occurring in hop gardens) which show symptoms suggestive of virus diseases has been commenced.

Apple scab.—In collaboration with the Chemical Research Department, spraying experiments have been continued, for the sixth year, in the College plantation at Wye. Similar plots of Allington and Newton Wonder have been sprayed respectively

with home-made Bordeaux mixture and a new oil-Bordeaux mixture. The crop was graded by hand for the amount of scab present.

At the request of the Ministry of Agriculture, and in co-operation with them and with members of the Kent county horticultural staff, a successful spraying demonstration, open to the public, was carried out in an orchard at West Farleigh, near Maidstone. A portion of the crop from the sprayed and all the crop from the unsprayed trees was hand-graded to ascertain the amount of scab present.

Pear scab.—A new fact in the life-history of the pear scab fungus (*Venturia pirina*) was discovered, viz.: its overwintering on the fruit-bud scales and young prolongations of the spurs. The discovery is of some importance as indicating the origin of early infections and may be of assistance in devising better measures of control. (6.)

Experiments with fungicides.—In collaboration with the Chemical Research Department biologically-controlled experiments have been carried out with the following substances:—glyceride oils (crude and refined), alcohols, phenols and copper derivatives.

Titles of papers issued during the year.

1. Martin, H., and Salmon, E. S.: The fungicidal properties of certain spray fluids, VIII. The fungicidal properties of mineral, tar and vegetable oils. *J. Agric. Sci.*, **21**, 638–658, Oct., 1931.
2. Ware, W. M.: Mushroom growing. *Bull.* 34, *Min. Agric.* (2nd Ed.), July, 1932.
3. Salmon, E. S., and Ware, W. M.: The hop downy mildew and its control—Addenda. (Supplementary to leaflet with above title, Feb., 1931.) *S.E. Agric. Coll.*, Dec., 1931.
4. ———: The downy mildew of the hop in 1931. *J. Inst. Brew.*, **38**, 28, 37–44, Jan., 1932.
5. ———: The chlorotic disease of the hop, II. *Ann. Appl. Biol.*, **19**, 1, 6–15, Feb., 1932.
6. ———: Scab on the spur wood and bud scales of the pear. *Gard. Chron.*, **91**, 2372, 446–447, June 11, 1932.
7. ———: The small hop disease. *J. S.E. Agric. Coll.*, 30, 22–27, July 12, 1932.
8. Goodwin, W., Salmon, E. S., and Ware, W. M.: The control of apple scab on Worcester Pearmain and Allington Pippin: A three years' experiment. *Ibid.*, 28–50, July 12, 1932.
9. ———: The control of apple scab. Allington Pippin and Newton Wonder. *Ibid.*, 51–62, July 12, 1932.
10. Martin, H., and Salmon, E. S.: The fungicidal properties of certain spray fluids, IX. The fungicidal properties of the products of hydrolysis of sulphur. July, 1932.

90. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Hill pasture investigations.—Investigations upon hill pasture problems at Boghall Glen were continued during the year. Progress

was made with the differentiation of vegetation types occurring in the glen and the study of their botanical characteristics. A vegetation map of the glen is in preparation. Some investigation of the productive capacity of a few of the pasture types was made by means of the netted enclosures periodically cut. Additional manurial experiments were begun and the irrigation experiments referred to in previous reports were continued and extended. The effect of combined irrigation and manurial treatment is under investigation.

Seeds mixture experiments.—The experiments referred to in last year's report were continued and a few additional experiments were begun. Botanical analyses of samples of the hay from certain centres are being made.

Experiments with rice grass (Spartina townsendii).—The initial success of the experimental plantings of rice grass in the Tay Estuary at Seaside, Inchture, has not been maintained, the plants having failed to survive the winter, even in situations where good initial establishment and growth had seemed to promise well. Only a very few plants survived into the second season out of a large number planted and these showed poor growth and no tendency to spread and colonise the bare mud.

Eradication of weeds by means of sodium chlorate.—The success obtained last season on small plots in the eradication of the annual nettle led to a more extensive trial being carried out this year. The results obtained last season were confirmed, viz., that the nettle can to a large extent be controlled by spraying with a 1 per cent. solution of sodium chlorate without permanent injury to Italian rye grass. Spraying was at the rate of 50 gallons per acre, and the nettles were much reduced, but not entirely destroyed. It is thought that a more complete eradication could be secured if a larger quantity of spray liquid were used. A few plants of groundsel and charlock which were present were also destroyed by the spray.

The sodium chlorate spray has been tested also upon a small scale on certain weeds growing in cereal crops. Charlock, in the rough leaf, growing among barley about 8 in. tall, was severely damaged and to a large extent killed by the use of a 1 per cent. solution. The barley suffered rather severe burning but made vigorous new growth and did not appear to be permanently injured. Weaker solutions were less effective. Very strong charlock in full flower, growing among oats, was severely injured but not entirely killed by spraying with a 1 per cent. solution. The oats were not badly injured but suffered some burning of the leaf tips. Cornflower, growing in wheat, was damaged but not killed by a 1 per cent. solution, the growing points of the shoot being protected by a thick felt of hairs. The wheat suffered rather severe burning. Buttercups were injured but not destroyed by solutions ranging from 1 to 4 per cent. The fronds of bracken were destroyed by spraying

with a 3 per cent. solution. A 1 per cent. solution was less effective, the pinnæ of the fronds being destroyed but the stalks surviving the treatment.

Some experiments were also conducted with a view to the eradication of perennial weeds by heavy dressings of sodium chlorate. Couch grass was not eliminated by winter dressings of from 1 to 2 cwt. although some reduction was effected. When dressings were applied in December, barley sown the following spring suffered injury. Bracken was much reduced but not entirely killed by dressings at the rate of 1½ cwt. per acre applied either in winter or when the fronds were coming up in spring. Lighter dressings were less effective. Sheep sorrel was largely killed out by applications of 1½ to 2 cwt. per acre, 1 cwt. per acre being less effective. The time of application did not affect the result to any marked extent. Seeds were not destroyed by the treatment and seedlings came up abundantly in the growing season following the applications.

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91. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Leaf stripe of oats.—The aspects of the disease which were investigated during this period were the examination of the various strains of the causative fungus *Helminthosporium avenæ* that are obtained when cultures of the organism are made. The growth and other characters of the fungus were found to show marked variation and the relative pathogenic virulence of these strains to oats was determined. It is definitely established by this work that there is a variation in pathogenicity between the strains, but that there is no relationship between the strains and the district in which the oats were grown and from which the strain was isolated. This is what would be expected in view of the fact that oat seed is very frequently changed—fresh seed being introduced from one district into another. It is quite common to find a large farmer in the south-west of Scotland having in the same year oats grown from seed from the Lothians, from Forfar, from Aberdeen, and from his own seed in neighbouring fields.

Other points under investigation were the possibility of infection remaining in the soil. It has been shown that it is possible for the fungus to remain in the soil on straw, chaff, etc., from the previous year's crop, but that there is no possibility of the fungus being able to grow therein. In other words the fungus is a true parasite on the oat plants and cannot live as a saprophyte in the soil. This undoubtedly makes control easier, as the infection is almost invariably carried on the seed except in the case of two oat crops being taken in succession, when there is a possibility of partial infection from the residue of the previous year's crop.

Many other points in connection with the biology of the fungus and its relationship to environmental conditions have been investigated and it is purposed to publish shortly a full report of the work.

Progress reports on the work on this disease appeared in the Journal of the Department of Agriculture, Vol. XV. No. 1, 1932, and Vol. XV. No. 4, 1932.

Eelworm disease of potatoes.—The previous work on the life history of the eelworm (*Heterodera Schachtii*) was published in 1931. Unfortunately the control of this pest is almost impossible under field conditions. During the year 1932 attempts were further made to combat this organism. Several soil disinfectants were tried out and while they were so strong as to injure the host plant yet they failed to have any influence on the parasite.

It has been concluded that it is impossible to combat this pest by chemical disinfectants and as has already been pointed out in previous reports, the only successful way to control the eelworm is by adopting a rotation in which potatoes are taken at the most every third year. This advice has been followed by many farmers on the Ayrshire coast and fields under potatoes for 30 or 40 years are now being put through a rotation with excellent results.

Titles of papers issued during the year.

1. O'Brien, D. G., and Dennis, R. W. G.: Control of leaf stripe or yellow leaf of oats. *Scott. J. Agric.*, **15**, 1, 39–45, 1932.
2. ———: Further experiments on leaf stripe of oats. *Ibid.*, **15**, 4, 406–410, 1932.

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VETERINARY SCIENCE.

92. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

Liver rot.—The wet season of 1931 provided both the need and the opportunity for further work on liver fluke. The system of preventive dosage with carbon tetrachloride worked out some years ago was very generally adopted throughout the province and proved effective in the majority of cases. The special nature of the season, in particular the occurrence of a period of comparative drought in September and October, following a period of heavy rainfall and flooding, led to several outbreaks of acute liver rot, against which the ordinary dosage is ineffective. In these cases the results of experimental work on the destruction of immature flukes were applied with good results. It is satisfactory to note that no case of poisoning occurred in these flocks dosed with even 10 c.c. per animal.

In the course of the work during the winter, conclusive evidence was obtained that in this season sheep became infected by ingesting cercarial cysts as late as the middle of April.

Liver rot was also common among young cattle and records were kept of 200 animals treated by carbon tetrachloride. These made a rapid response to the treatment, and, although some showed mild toxic symptoms, not one died of poisoning.

Pulpy kidney disease ("strike") in young lambs.—Full advantage could not be taken of the careful preparations made for the further study of this condition on account of the low incidence of the disease. The frequency of something highly toxic in filtrates of intestinal contents from these cases was confirmed. This toxicity was not neutralised by any of the antitoxins available but that prepared from *B. welchii* (*lamb dysentry*) did appear to influence it. Mice injected with filtrate plus this antitoxin survived longer than did control mice injected with filtrate alone or with filtrate plus another antitoxin. Intestinal filtrate from cases of lamb dysentry was readily neutralised by this antitoxin.

The disease was reproduced in lambs by the inoculation of intestinal filtrates from two cases of pulpy kidney disease.

Braxy.—The trials of *Vibrion septique* anaculture in the prevention of braxy gave very satisfactory results and further observations in new districts have been undertaken.

Toxaemia of pregnancy in ewes.—The very low incidence of this disease during the last lambing season is of particular interest. This appears to be closely related to the fact that ewes of the type prone to this disease came to the ram in relatively low condition. Further, on account of the very open winter and early spring, they were easily able to maintain their bodily condition throughout pregnancy.

Lamb dysentery.—A new procedure in the diagnoses of lamb dysentery has been adopted. When this disease appears ina farm or

district hitherto clean it is of great importance that the diagnosis be established beyond doubt with as little delay as possible. The determination of high toxicity in filtered intestinal contents and the neutralisation of that toxicity by *B. welchii* (*L.D.*) antitoxin, together with the failure of *B. welchii* and other antitoxins to neutralise, is a firm basis for very early and accurate diagnosis.

Contagious Abortion. Segregation method of control and eradication.—In view of the necessity to reduce expenditure it was decided to concentrate on those few of the 47 infected herds under observation in which it seemed likely that further work would lead to success in eradicating the disease. Seven herds remain in the scheme and in four there is reason to believe that eradication has been effected. In the remaining three an occasional new reactor is still encountered.

Titles of papers issued during the year.

1. Montgomerie, R. F.: On the longevity of *Fasciola hepatica* in experimentally infested rabbits. *J. Helm.*, **9**, 4, 209–212, Nov., 1931.
2. Montgomerie, R. F., and Rowlands, W. T.: A comparison of the blood and milk agglutination test in the detection of bovine contagious abortion. *Vet. J.*, **88**, 6, 227–236, June, 1932.

93. BRISTOL UNIVERSITY.

Vaccination of lambs against contagious pustular dermatitis has been carried out on one farm. The strain of virus on this farm was found to be more virulent than is usual, so that while the vaccine did not completely protect against infection there was a pronounced moderating influence on the course of the disease.

A survey of the infestation of sheep with parasitic worms, as revealed by the egg counts, has been carried out on a few farms.

Johnin tests have been performed where Johne's disease was particularly rampant in an effort to detect non-clinical cases of the disease.

94. CAMBRIDGE UNIVERSITY.

" Lactation tetany " in cattle.—This disease was responsible for serious loss during the spring. The symptoms and epizootiology of the complaint were studied and several post-mortem examinations made. Much valuable evidence was collected and the investigation will be continued if further outbreaks occur.

" White Scour " of calves.—Several outbreaks have been investigated. In the majority of cases a history of faulty management was obtained, but on one farm the disease was found to be due to infection with *B. enteritidis* (Dublin), an organism of the food-poisoning group.

" Blood tumours " in poultry.—Six outbreaks of this condition have been studied. On examination the tumours were found to be *hæmangiomata* and an article containing the details of this work carried out has been published. (1)

Parasitic diseases.—In view of the alleged connection between intestinal parasites and other diseases of poultry, a survey is being made of the parasites present in various diseased conditions.

Title of paper issued during the year.

1. Blakemore, F., and Innes, J. R. M.: A preliminary not on blood tumours (*Hæmangio-endothe liomata*) in the fowl. *Second Rep., Inst. Animal Path.*, 1931.

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95. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES.

Sheep Diseases.

Marsh disease (?).—The name of this condition is queried because its true identity has not yet been established. For many years it has been known in the districts in which it occurs as " murrain." Investigations carried out by the Department show, however, that it is definitely not true blackleg. The condition shows certain resemblances to the " marsh disease " described by Mr. A. D. McEwen. Unfortunately, however, owing to the seasonal occurrence of the disease, the supply of material for examination was exhausted for the season before definite conclusions could be arrived at. It is hoped to carry out further investigations in the near future.

" Sway-back "—Investigations are still proceeding into this condition, and additional data have been obtained from several affected areas.

Broncho-pneumonia.—Investigations are still proceeding into the possible connection of this condition, when it occurs in the summer, with the larvae of *Oestrus ovis*. It is interesting to note that the number of cases occurring during the past summer were very few. This would appear to lend a certain amount of support to the theory that the condition is more prevalent in a year following a bright, dry summer.

Poultry Diseases.

Bacillary white diarrhoea.—Forty-seven outbreaks were investigated. A much larger proportion than usual of the cases showed nodules in the lungs and heart. Over two thousand fowls from breeding stocks were subjected to the agglutination test. The evidence collected to date has clearly demonstrated the value of a double test in controlling the disease.

Leukaemia.—The number of cases of this disease has been rather higher than during last year. There have also been more instances of several fowls from the same flock being affected. Investigations are in progress on the subject.

Fowl paralysis.—Several outbreaks of so-called fowl paralysis have been investigated. *Coccidia* were found in all cases on post-mortem examination. In one individual case, however, the cerebellum was apparently involved as the fowl persisted in turning back-somersaults. A cinematograph film was taken of this bird.

Coccidiosis.—Numerous outbreaks of this disease among both chicks and adult stock have been investigated. The disease certainly appears to be more prevalent than it was a few years ago. In chicks the condition has undoubtedly been checked by the administration of iodised milk but a large number of outbreaks in adult stock occurred in flocks in which this treatment had apparently eradicated the disease in young chicks. It is still doubtful, therefore, whether iodised milk eradicates the disease completely or merely checks it for the time being. No treatment has so far been of any value in controlling the condition in adult stock.

Miscellaneous.—Work was also carried out on tuberculosis, fowl typhoid, tumours, diphtheritic roup and fowl pox.

Cattle diseases.

The diseases investigated were fascioliasis, septic pneumonia, redwater and Johne's disease.

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96. HARPER ADAMS AGRICULTURAL COLLEGE.

Johne's disease.—The investigations in connection with the use of "Johnin" as a diagnostic agent have been continued. In all post-mortems on animals which had given positive reactions to the test characteristic lesions affecting the intestines and mesenteric glands were found, and Johne's disease bacilli were demonstrated microscopically.

Tuberculosis.—Observations with organisms of the acid-fast group other than tubercle bacilli have revealed an acid-fast group reaction which may be produced by animals suffering from either tuberculosis or Johne's disease following the injection of the growth products of acid-fast organisms into the skin. These reactions may help to explain the doubtful swellings which are sometimes obtained in the use of the tuberculin test.

Tests on fowls with avian tuberculin tended to show that this test is less reliable as a diagnostic agent than the cattle test.

Fowl paralysis.—Many flocks were found to be heavily infested with *Davainea proglottina.* Many cases of fowl paralysis were

found to be associated with chronic coccidiosis, especially where the attack was located in the duodenum. A few outbreaks have been studied where ascarid and capillaria worms were the chief parasites present.

Anaemia of fowls.—In a test with three pens of eight birds, all suffering from anaemia, some improvement was effected by feeding fresh ox liver or hog's stomach, but none with milk.

Titles of papers issued during the year.

1. Downham, K. D.: Diseases of poultry and their danger to the larger animals. *J. Brit. Dairy Farm. Assoc.*, **44**, 42–45, 1932.
2. Downham, K. D., and Botham, G. H.: A description of apparatus of value in the rapid conduction of the agglutination test. *Veter. Rec.*, **12**, (N.S.), 1082–1084, 1932.
3. Downham, K. D., and King Wilson, W.: A note on deaths in a stock of albino angora rabbits receiving sugar beet tops in the ration. *Veter. J.*, **88**, 6, 263–267, 1932.
4. Downham, K. D.: Pericarditis of the fowl. *Ibid.*, **88**, 1, 44, Jan., 1932.

97. LEEDS UNIVERSITY.

Tremblings or moss illness in ewes.—This disease was not so prevalent in the lambing season of 1932 and opportunities for experimental treatment were therefore limited. The term probably includes two distinct diseases, viz., pregnancy toxaemia and lambing sickness. In the latter disease treatment by inflation of the udder with air, or by the injection of calcium gluconate solution, proved very successful. Cases of pregnancy toxaemia (chiefly indicated by their occurrence before lambing) do not, however, respond as constantly to either of the above treatments.

Deficiency diseases.—Several outbreaks of disease amongst cattle were investigated which appeared to be due to mineral deficiencies. In one of these several cattle showed symptoms of tetany and an analysis of blood samples from these cows carried out at the Moredun Institute revealed a magnesium deficiency.

Poisoning.—Several cases of suspected poisoning were investigated in collaboration with chemical and botanical colleagues on the staff of this department. Amongst these were cases of linseed poisoning in calves.

Crook in lambs.—This disease which occurs in various parts of the country is a septic infection of young lambs, better known as navel-ill. Preventive treatment by dressing the navel shortly after birth with powdered copper sulphate has proved very effective.

Title of paper issued during the year.

1. Bowes, H. G.: A few notes on some of the common sheep diseases met with in Yorkshire. *Veter. J.*, **88**, 5, 209, May, 1932.

98. LIVERPOOL UNIVERSITY.

The eradication of Johne's disease from selected farms by means of the double intradermal test and technical advice on herd management has been continued. This work has been supplemented by an extension of the enquiries relative to a possible connection between pathogenic and non-pathogenic members of the acid-fast group of bacilli.

Investigations into the value of the B.C.G. method of vaccination as a means of diminishing losses due to tuberculosis have been discontinued, but the adviser will still supply vaccine and carry out post-mortems on vaccinated animals. Advice will also be supplied on application and details of the system given to farmers and veterinarians adopting it.

Diseases of swine are reported to be of increasing importance. An investigation was commenced into a condition met with in growing stock resembling a Vitamin A deficiency. The eradication of ascaris infection from a herd of swine was continued and the system evolved gave a high degree of success.

The epizootiology of bovine arthritis and bursitis is now being investigated, especially in connection with the possibility of *Brucella abortus* infection of the joint.

Minor investigations have dealt with the control of streptococcic and summer mastitis, control of Bang's disease and poultry diseases, especially coccidiosis. Cases of suspected cake poisoning have been investigated.

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99. MIDLAND AGRICULTURAL COLLEGE

Cattle.—

B.C.G. vaccination.—This work has been continued and during the year one vaccinated animal has become available for post-mortem examination. This examination showed no evidence of tuberculosis.

Johne's disease.—Two herds have been tested with Johnin. Only two post-mortem examinations have been made—one on a reactor and one on a non-reactor—and the findings agreed with those of the test.

Summer mastitis.—Preventive treatment was applied experimentally to a herd of cows, but no results were obtained.

Bracken poisoning in cattle.—An alleged outbreak causing the death of three cows was considered, on investigation, to be lead poisoning.

Sheep.—

Deaths of inlamb ewes.—An investigation was made into serious losses that were sustained in a flock of ewes. The flock consisted of about 150 animals of which about half had been bought in from

Scotland in autumn. The losses were confined to these bought in animals and took place in the spring at about lambing time. The outbreak was almost at an end before the investigation was instituted and only one case of illness was observed. A post-mortem examination was made on this animal but the results were inconclusive.

Pigs.—

Enquiry was made into the cause of sudden deaths in adult pigs and it appeared that the cause was food poisoning due to feeding decomposing household waste.

Poultry.—

Avian tuberculosis.—Some trial has been given to avian tuberculin. The technique recommended, i.e., injection into the wattle, did not give clear cut reactions and was modified to injection into the infraorbital region. Using this modified technique, the reactions were found to be very distinct. A number of post-mortem examinations have been made, both on reactors and non-reactors, and the findings have in the main agreed with those of the test.

Titles of papers issued during the year.

1. Ironside, W. J.: Common diseases of poultry. Handbook for poultry-keepers. *Notts. Educ. Ctee.*, 1932.
2. ———: Summer mastitis. *Derbyshire Young Farmer*, 174, June, 1932.

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100. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Anaerobic diseases of sheep.—Further field experiments to test the value of artificially conferred immunity in the prevention of certain anaerobic diseases of sheep have been carried out. In the case of several sheep farms notorious for braxy, satisfactory results followed the use of a suitable vaccine used before the commencement of the braxy season. In the spring another experiment was carried out into the prevention of this disease in young lambs. No definite conclusion as to the value of vaccination was arrived at, but in view of its importance it is proposed to continue these experiments for another year.

Louping ill.—In connection with the well-known disease of sheep called "louping ill," research has advanced to such a stage that practical immunisation is being attempted, and the adviser conducted a controlled experiment on 12 infected farms. One half the number of young sheep received treatment and the remainder were untreated to serve as controls. The results indicated that a degree of immunity had been conferred on the vaccinated group, but the experiments require repetition and amplification.

Contagious dermatitis.—The prevention of contagious dermatitis of the sheep has also received attention, and it is hoped that prophylaxis against this disease will soon be placed on a satisfactory basis.

Miscellaneous.—Investigations into swingback (ataxia) in lambs, cripples in lambs and contagious bovine abortion have been continued throughout the year.

Title of paper issued during the year.

1. Stewart, W. L.: Swingback (ataxia) in lambs. *Veter. J.*, 88, 4, 133, 1932.

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101. SEALE HAYNE AGRICULTURAL COLLEGE.

Poultry.—The majority of the investigational work done by the department has been of a diagnostic nature and mainly related to poultry. It has therefore been chiefly laboratory work, and when preventative measures have been necessary, co-operation of the county poultry instructors has been given in supervising these measures.

Apart from these investigations of outbreaks of poultry disease, routine testing of poultry for " B.W.D." has been carried out by a staff supplied by the College, and all work in connection with these agglutination tests has been supervised by the Department.

Cattle.—An investigation on the effect of vaccination upon the incidence of contagious abortion by the use of " dead " vaccines is being carried out with two dairy herds, one affected about two years ago and the other only recently. Two types of vaccine are being used, and both have been prepared from the strain of germ affecting the long-standing outbreak. One is formalised and the other phenolised. Both types were prepared by the Veterinary Laboratory of the Ministry of Agriculture. Results are being followed by the agglutination test of vaccinated animals at fortnightly intervals.

Sheep.—Mineral deficiency diseases of sheep are being investigated with representative animals of eight Dartmoor flocks of sheep. Samples of blood and pasture grass are being collected, more or less coinciding with the various movements of the sheep between different types of pasture (moorland, enclosed Dartmoor farm and " in-country " pasture takes). Other factors, such as soil analysis, botanical analysis and meteorological data will be co-related with any findings that result. The necessary analytical work as regards the blood and pasture in this investigation is being carried out by The Institute of Animal Pathology, Cambridge.

Miscellaneous.—Investigational work has been done with other farm stock and also silver foxes.

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102. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE.

"*Struck.*"—During the past season the incidence of the disease was low and on account of this field vaccination experiments did not yield definite results. Occasional cases of sudden death from unknown causes were investigated but only negative information was obtained.

The disease "struck" has been produced by feeding comparatively small quantities of the causal organisms when these were enclosed in gelatin capsules. Previously it had been necessary to feed several liters of culture to produce this disease.

The disease has not been produced by feeding bacteria or toxin to lambs fed on a diet of pure protein, pure carbohydrate or a balanced diet. These experiments on lambs and other feeding experiments with sheep failed to show that the nature of the diet influenced the susceptibility of the sheep to alimentary infection with the causal organisms of "struck."

Experimental sheep were satisfactorily immunised against the oral administration and against parenteral inoculation of the organisms.

Gangrene.—*B. chauvoie* was further incriminated as the cause of gas gangrene in ewes and lambs. Passive immunisation of ewes with immune serum is of material aid in controlling the disease in these animals.

Miscellaneous.—Efforts to eradicate contagious abortion from herds of cattle have been continued and immunisation against this disease is receiving attention.

Enquiries on abortion among ewes and Johne's disease have occupied a considerable portion of time.

Parasitic worm infestation of poultry, coccidiosis of poultry and parasitic worm infestation of sheep have also received consideration.

Titles of papers issued during the year.

1. McEwen, A. D.: The ætiology of the braxy-like diseases of sheep. *Vet. J.*, **180**, 192, 1932.
2. ———: Anærobic infections of sheep as seen on the Romney Marsh. *Nat. Vet. Med. Assoc. of Great Britain and Ireland 50th Annual Congress*, 1932.
3. McEwen, A. D., and Roberts, R. S.: Gas gangrene in sheep. Passive immunisation. *J. Comp. Path. and Therap.*, **45**, 212, 1932.

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AGRICULTURAL and DAIRY BACTERIOLOGY.

103. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES.

Pasteurisation of cream for household use.—The influence of different methods of pasteurisation and cooling on the keeping quality and viscosity of cream for household use is being studied. Cream pasteurised, cooled and distributed in air tight glass containers has been found to keep exceptionally well. An attempt is being made to improve the viscosity of such cream.

Grading of milk on microscopical examination.—A simple method of grading milk on direct microscopical examination is being compared with the present routine methods. Results show that this method can be used in conjunction with the reductase test with advantage at cheese factories.

"Ropy" milk.—The persistence in water and the heat resistance of certain strains of ropy organisms is being investigated. Some of these organisms have been found capable of producing marked ropiness in milk after being kept in water for over nine months. Old cultures resist pasteurisation at 62.8° C. for twenty minutes.

Presence of thermophilic bacteria in raw milk.—The number on thermophilic bacteria (growing at 55° C. for 48 hours) present if two types of market milk has been studied. Ordinary raw milk was found to contain such organisms in 75 per cent. and badly pasteurised milk in 96 per cent. of the samples examined. Thermophilic organisms have only very rarely been found in a series of clean milk samples.

Title of paper issued during the year.

1. Thomas, S. B., Hickson, P. M., Sugden, J. H., Catto, H., and Sladden, A. F. : Some aspects of the graded milk movement in Wales. *Welsh J. Agric.*, **8**, 214–222, 1932.

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104. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

"Cheesy" taint in cream and butter.—In a case of "cheesy" taint investigated the suspected cause was a cow with slight udder infection, but the removal of this cow's milk from the bulk did not result in a removal of the trouble. It was finally traced to an external contamination of the udder, which had its source in marshy land to which the cows had access when grazing. Advice was given regarding the necessity for cleanliness in cowshed and dairy, and this was followed by a marked decrease in the taint. At this point in the investigation the cows were brought in for the winter and the taint disappeared completely, and there has been no further recurrence during the ensuing summer months.

Rapid souring of milk.—On investigation the cause of souring was traced eventually to a single cow in the herd suffering from an udder infection. Utensils had become contaminated and the whole of the supply was being affected. After the removal of the affected cow from the herd, and the sterilisation of all utensils, no further trouble was experienced.

"Ropy" milk.—An outbreak of "ropy" milk was traced to surface water in the field and yard to which the cows had access. The conditions in the dairy were good and sterilisation efficient, but the methods of production in the cowshed left much to be desired. Washing water from the cows inoculated into sterile milk produced a ropy condition. With improved conditions in the cowshed, the trouble was eventually removed.

Title of paper issued during the year.

1. Thomas, S. B., Hickson, Phyllis M., Sugden, J. H., Catto, H., and Sladden, A. F.: Some aspects of the graded milk movement in Wales. *Welsh J. Agric.*, **8**, 214–222, 1932.

105. BRISTOL UNIVERSITY.

Methods of examination of milk samples.—Work continues on the methods employed in the examination of samples submitted in connection with the register of accredited producers in Wiltshire. The new scheme of testing samples by the reductase test in combination with the coliform test in the 1/100th dilution only has been put into operation on an experimental basis and the examination of a proportion of the samples received has been duplicated by the plate count and full coliform test. It is hoped, when the full complement of samples to be submitted during the year has been received, to examine the figures obtained, and judgment of the scheme is reserved until these figures have been studied.

Thermophilic organisms in milk.—The work on thermophilic organisms, which was begun at an earlier date and had to be suspended, has been recommenced and a considerable amount of preliminary work, in the nature of reviewing the literature and investigating methods of procedure, has been accomplished. It is hoped to proceed with this work as time permits.

Coagulation in sterilised milk.—Arising out of an enquiry from a dairy company sterilising milk in Bristol, an interesting investigation is proceeding as to the cause of a coagulation of somewhat unusual type in the sterilised milk after heat treatment and storage. Although the original outbreak of this trouble was brief and not of very serious dimensions, several unusual features make it of particular interest both from the scientific and practical points of view.

Title of paper issued during the year.

1. Miles, C. S.: The freezing point of milk and its use in the detection of added water. *Gloucester Students Assoc. Mag.*, April, 1932.

106. CAMBRIDGE UNIVERSITY.

Butter-fat content.—Some 3,200 individual tests of Friesian milk, analysed by the Department, have been reviewed in eight groups, viz., four seasonal classes for morning and evening respectively.

Statistical treatment clearly shows that the morning samples generally exceed the presumed legal standard of 3 per cent. by only a small margin—the mean of a group of 491 morning samples taken during April, May and June actually fell below 3 per cent.

A subsequent analysis of the results of some 6,000 tests on samples taken from Shorthorn herds has disclosed no such danger. Work is in progress on the correlation of yield and butter-fat percentage—the data being classified according to the progress of lactation.

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107. HARPER ADAMS AGRICULTURAL COLLEGE.

Cleanliness of milk churns.—Ninety-two churns on 16 farms have been examined as soon as possible after return by the retailer. On nine farms two tests, one in winter and the other in summer, have been made. These indicate that in most cases contamination from churns is small during the winter, but in summer may be considerable. The poor summer results were all obtained from hand-washed churns.

Mastitis.—Promising results have been obtained in conjunction with the veterinary adviser in the use of an " autogenous vaccine " consisting of the milk from the infected quarters, heated to 60° C. for one hour.

Preservation of duck eggs.—Work previously initiated in co-operation with the National Institute of Poultry Husbandry has been continued and previous observations confirmed as to the greater liability of duck's eggs to deterioration during storage than hen's eggs.

Fermentation tests of milk.—Results from 200 fermentation tests showed very poor correlation with the plate count and coli test, but the test would nevertheless appear to be of some value in dairy plant control.

Reductase test.—A small amount of work has been done on the methylene blue reductase test at 15° C. with a view to comparing its agreement with the keeping quality test. Correlation so far is reasonably good, but the question of the optimum concentration of methylene blue requires investigation.

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108. LEEDS UNIVERSITY.

The problems which have been investigated during the year were concerned with the cause of (i) poor keeping quality of milk, (ii) sliminess of cream, (iii) taints and abnormal flavours in milk and cream, and (iv) the detection of latent mastitis in milch cows.

In the majority of the cases of poor keeping quality and abnormal taint the cause was generally found to be insufficient preparation of the cows and unsterile utensils. In almost every case the responsible organism was *Bacillus coli*.

Further work has been carried out on the significance of *B. coli communis* and *B. lactis ærogenes* in milk. Attempts have been made to modify the " presumptive " coli test with the object of determining the extent to which samples of milk are infected with these organisms. The addition of telluric acid and brilliant green has proved useful in this respect, but much work still remains to be done on the origin and significance of those coliform organisms which are intermediate between the true *B. coli* and the true *B. lactis ærogenes*.

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109. MIDLAND AGRICULTURAL COLLEGE.

An unusual source of B. coli in milk.—The source of infection of Grade A milk with organisms of the *coli ærogenes* group was shown to be a single cow with a damaged teat end. It was demonstrated that if the damaged teat was thoroughly cleaned and disinfected with methylated spirits, it was possible to obtain milk from the quarter which was free from coli. It was therefore evident that the infection was confined to the teat canal and had not invaded the quarter.

Mastitis.—Investigations in the course of clean milk competitions have shown that the presence of a large number of minute pin point colonies on the first and second plates of the Agar count of bacteria in milk is frequently an indication of udder trouble in a herd. In several cases this observation has been confirmed by the use of the Brom Cresol test, and microscopic examination of milk from individual cows from suspected herds.

Bacteriological examination of milk at different ages.—Investigations have shown that milk even when kept at 60° F. gives very much higher counts at 24 or 27 hours old than when examined a few hours after milking. Public health authorities usually examine milk at a few hours old, and the excellent results that have been obtained by such authorities on milk from average producers as compared with those obtained by advisory bacteriologists can be accounted for by the difference in the age of testing.

The methylene blue reductase test and its uses for testing milk.—This test, in conjunction with the keeping quality test, is being used

at one dairy in Lincolnshire as a basis of payment for milk. Investigations are in progress to ascertain whether this method is satisfactory for this purpose.

Titles of papers issued during the year.

1. Rowlands, A.: Cleanest milk competition, 1931. Inspecting judge's report. *Derbyshire Farmer*, **12**, 6, 1932.
2. ———: Some bacterial aspects of milk pasteurisation. *Ibid.*, **12**, 9, 1932.

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110. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Solids-not-fat content.—A test of six weeks' duration during the winter was made on a tuberculin tested herd, at the special request of its owner, to ascertain whether the solids-not-fat content of milk could be raised by feeding additional minerals.

Although it had been proved by former experiment that such a result could not be achieved, it was thought worth while to carry out the investigation in the hope that some facts of interest might emerge.

Additional minerals and additional minerals plus cod liver oil gave no increase in solids-not-fat, but the addition of cod liver oil tended to depress the butter-fat content of the milk. A further test on this problem, but on different lines, is in contemplation.

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111. READING UNIVERSITY

Duplicate testing scheme.—This scheme which consists of testing eleven portions of the same sample has been temporarily suspended until the statistical analysis is complete. The statistical examination is now in progress with the co-operation of the London School of Hygiene and Tropical Medicine and the results will be available in the near future.

Reading duplicates.—This forms part of the larger duplicate testing scheme and consists of the testing in duplicate of two portions of the same sample in the laboratory at the National Institute for Research in Dairying. The statistical examination of the collected results of this work is now complete.

Correlation scheme.—This scheme involves the collection, at the National Institute for Research in Dairying, of the results of bacteriological examinations done by advisory bacteriologists in connection with clean milk competitions. The initial work of arranging the results in a form suitable for statistical treatment is well advanced but the statistical work cannot be proceeded with until the results

of the duplicate testing scheme and the Reading duplicates are known.

Testing of ice cream.—During the summer a number of tests were carried out in order to find the most suitable outfit for the collection and transport of samples of ice cream. The bacteriological examination was carried out on weighed and measured samples in order to determine which was most suitable for laboratory conditions at the National Institute for Research in Dairying. This work will be continued next season.

Methods of hand-milking.—In co-operation with the Hampshire Dairying Superintendent tests of milk produced by different methods of hand-milking were carried out to determine the method best suited to the production of milk of low bacteriological count. The results show that milking with dry hands is superior to milking with wet hands or with greasy hands (lubricated with grease).

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112. SEALE-HAYNE AGRICULTURAL COLLEGE.

Bitterness in clotted cream.—Several cases of this taint have been investigated and it was generally found to be due to the presence in the cream of a spore-forming organism of *B. mycoides* type.

The chief sources of contamination were found to be—

(i) The coats of the cows when pastured in wet marshy meadows.
(ii) The cream being placed to "set" in places where it is liable to become contaminated with dust.
(iii) The water supply used for washing the utensils.

Bacteriological control of pasteurising plants.—This work chiefly consisted in tracing the sources of recontamination of pasteurised milk, as in all cases investigated the actual pasteurising was found to be carried out efficiently. The chief sources of recontamination were found to be :—

(i) The cooler.
(ii) Faulty sterilisation of bottles.
(iii) The bottle-filling machine.

In some cases recontamination was so extensive that the pasteurised milk was bacteriologically as dirty as the raw product.

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113. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Ropiness of milk was fairly prevalent, five cases having been dealt with.

Other interesting cases were (i) contamination of milk from a certified herd where a milking machine was used; although usual

precautions were taken, it was eventually shown that sterilisation, to be effective, must be for 20 minutes holding at 210° F.; (ii) trouble due to thermoduric streptococci in dairy-pasteurised local milk. Faulty methods in the dairy were disclosed.

Simultaneous tests by standard method, Guide 3rd Ed., and by Van Oijen technique were continued; 345 Van Oijen tests were made, using competition and private senders' results for the standard count, and also 144 samples from a local creamery were specially tested to be included in the work. These results are under discussion.

Title of paper issued during the year.

1. Barkworth, H.: Seven years' study of keeping quality tests. *Agric. Prog.*, **9**, 93–95, July, 1932.

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114. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Milk faults.—An aroma resembling that of amyl alcohol.—Further work was carried out with the micrococcus referred to in previous reports in an endeavour to obtain information as to the nature of the substance from which the aroma is produced. In the alcoholic fermentation the constituents of the so-called "fusel oil," which possess a similar aroma, have been shown to be formed from the amino-acid leucine. In the present instance it was found that the micrococcus isolated was also capable of producing the characteristic aroma from leucine. A report on this taint will be published shortly.

The Burri smear-culture method for determining the bacterial content of milk.—Work on this subject has been continued during the year and has yielded results in agreement with those referred to in the report for 1930–31. The effect of the use of media, other than that generally employed for determination of the bacterial content of milk, upon the accuracy of the method is at present being investigated.

Coliform organisms in milk samples.—Although investigations with regard to the proportions of coliform organisms of faecal and non-faecal origin in milk have been carried on for some years, the work has been considerably retarded owing to the lack of a satisfactory selective solid medium for the direct isolation of such organisms from samples. Hitherto MacConkey's broth has been employed for the preliminary cultivations from milk, but in the case of isolations made from this medium after 24 or 48 hours' incubation, there is no assurance that the various types of coliform organisms will be obtained in the proportions in which they existed in the original milk sample. There is also some evidence that the bile salt in MacConkey's medium may exercise an inhibitory influence upon certain types of coliform bacilli. Further, there is no certainty that the results obtained by the use of this medium

may not in some cases be attributable to the growth of organisms other than coliform bacilli. The above considerations, as well as certain other disadvantages of the method generally in use, made it appear desirable to attempt to find a more satisfactory technique. An investigation of a number of selective solid media which have been recommended for the isolation of coliform bacilli from water, faeces, soil, milk, etc., was therefore undertaken. This work was carried out by Dr. G. Glathe of Leipzig University, who spent the summer months in this Department. Promising results were obtained with a modification of the solid medium which has been recommended by Klimmer and his co-workers in Germany. The data obtained are now being prepared for publication.

Cultivation of lucerne and other leguminous crops.—The usual advisory work regarding sowing, cultivation and inoculation of lucerne was carried out. Cultures for the inoculation of clovers, tares, peas, trefoil, kidney vetch, lupins, lucerne, sweet clover and serradella were supplied to the Macaulay Demonstration Farm in Lewis.

The anaerobic bacilli of farmyard manure.—From February until September 1932, Dr. Hans Glathe of Leipzig University worked in the Department on this subject. No thorough systematic investigation of the anaerobic bacilli of farmyard manure has previously been carried out and the information on the subject is fragmentary and in the main unreliable. In the period available preliminary studies only could be undertaken but they have already served to show that the anaerobic flora of manure is considerably more numerous and varied than had previously been supposed. These preliminary studies are now in course of completion and it is hoped that it may be possible to publish a note on the results during the coming year.

The filterable stages of bacteria.—At the International Dairy Congress in Copenhagen in July, 1931, Professor Sherman of Cornell University read a paper on the filterable or virus forms of bacteria in milk and milk products. The presence of filterable stages in raw milk, sour milk, aseptically drawn milk, butter, cheese and ice cream was demonstrated by the use of a special technique. The forms in question were shown to occur in milk and milk products in much larger numbers than the ordinary bacteria. Their numbers varied from 10,000,000 to 1,000,000,000,000 per c.c or gram of the various substances examined. During the past year repeated attempts have been made to cultivate filterable forms from milk by means of Sherman's technique as well as by that which the French worker Hauduroy has employed for the cultivation of filterable stages from bacterial cultures. In all cases, however, the results have been negative. An examination was also made of the method suggested by P. Kuhn in Germany for growing filterable phases from cultures of bacteria. These experiments also yielded negative results.

The identity of Bacillus putrificus Bienstock.—In the literature dealing with the anaerobic putrefactive bacilli there has for many years been considerable controversy as to the identity of the putrefactive bacillus described by Bienstock. In the course of studies on the life-cycle of *B. saccharobutyricus* an anaerobic sporulating rod was encountered, the characteristics of which corresponded more closely with Bienstock's description of *B. putrificus* than do those of any other organism hitherto described. Detailed studies of this bacillus were made, the results of which were published in July 1932 (1).

Titles of papers issued during the year.

1. Cunningham, A.: The identity of *Bacillus putrificus* Bienstock. *J. Bact.*, **24**, 61–70, 1932.
2. ———: The Stassaniser. *Scot. J. Agric.*, **15**, 292–295, 1932.
3. ———: Report on the Ninth International Dairy Congress and a visit to Denmark. *Dept. of Agric. for Scotland*, 1932.

115. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Milk Production.

Protein supply.—The protein supply for the dairy herd is especially important, as concentrates of high protein content have to be purchased in considerable quantities to balance the ration of most dairy herds. It has been found by this Department that an allowance of 20 per cent. digestible crude protein in the concentrate ration of dairy cows induces rather greater milk production than does an allowance of 15 per cent. of digestible crude protein. During the past year rations containing approximately 17 per cent. and 22 per cent. of digestible crude protein have been compared and it has been found that the lower allowance induces heavier milk production than does the larger. This would appear to indicate that in the balancing of home-grown rations the concentrate mixture should contain somewhere between 17 and 20 per cent. of digestible crude protein. It is hoped to investigate this problem further during the coming year.

Calf rearing.—In milk selling districts it is sometimes difficult to get milk for calf rearing when prices are good. As a consequence trials have been started on the rearing of calves with a minimum amount of milk. It has been found that young calves thrive better and make more economical gains on whole than on ground grains. During the past year, therefore, in a trial with calves on a limited milk allowance the milk has been taken away at the end of a few weeks and replaced by a mixture consisting of equal parts of whole maize, whole oats, nutted linseed cake, wheat bran and skim milk powder. The calves made reasonable live weight gains on this ration.

Dried beet pulp.—In the past the dried beet pulp purchased for use on dairy farms has generally been soaked before feeding. A trial conducted during the past winter has shown, however, that where water bowls are provided, up to 6 lb. of beet pulp can be fed in the dry state with satisfactory results.

Pasteurised milk.—Though the pasteurisation of milk for human consumption has received great attention, very little experimental work has been done on the use of pasteurised milk in calf rearing. As a consequence a preliminary trial in which raw and pasteurised milk were compared was conducted last spring. The calves on raw milk all lived and made reasonable gains, while three out of eight calves started on pasteurised milk at five days of age died. Those surviving made almost as good gains in the early stages of the trial as did those on raw milk, but towards the end of the trial, which lasted 90 days, the calves on pasteurised milk did not make as good gains as those on raw milk. It is hoped to continue this work on a larger scale.

Hoven in dairy cattle.—Hoven, or bloat, is particularly prevalent amongst dairy cattle in certain districts. A survey was started in the Rhinns of Galloway in 1929 and the results of this have been presented for publication. The conditions under which bloat is most likely to occur are outlined and methods of prevention and treatment suggested.

Hoven occurs most frequently on pastures containing large amounts of wild white clover, though it can occur on other pastures. Laboratory work appears to indicate that hoven is probably primarily due to a saponin in the feed preventing the escape of gas from the rumen. Work on this problem is being continued.

Proven sires.—Much work has been done in this Department on the records published by The Scottish Milk Records Association. Now a start has been made in the preparation from these of a list of good dairy sires. The standard required for the bulls is a minimum of ten daughters, each of which has a record of at least 280 lb. of butter fat in her second or a later lactation, or two-thirds of that amount as a heifer.

So far the daughters of 750 Ayshire bulls have been studied, and it is found that only 42 of these bulls come up to the standard set. It is hoped to carry this work to completion in the near future.

Milk Utilisation.

Market milk investigations.—Flavour defects in market milk, referred to in previous reports, continue to cause serious economic losses to milk producers and milk dealers.

An Ayrshire creamery reported the total loss of one day's milk supply owing to the development of a pronounced foreign flavour which rendered the bulked milk unmarketable. At the request of the creamery management, a visit was paid to the depôt and the

plant and processing inspected. While certain minor defects in the equipment were observed and indicated, a careful laboratory examination and analysis of the milk of the individual suppliers showed that the fault could be traced to the quality of the milk furnished by some of the patrons. The faulty milks—rendered defective mostly by udder disturbances in the producing cows—were indicated, and the suppliers were advised at a specially convened meeting of appropriate control measures which should be adopted. Two subsequent examinations were made of each supplier's milk and any weaknesses, still detectable by laboratory examination, indicated. As a result of these measures the trouble was overcome. As indicative of the prevalence of such troubles, it may be said that of the 357 samples of farm milk and the 174 samples of milk of individual cows sent for examination to this laboratory during the past year, fully 40 per cent. of those exhibiting a faulty flavour showed clear evidence of udder disturbances in the producing herds of cows. Contagious mammitis is, according to our experience, the chief form of udder trouble in the milk producing herds of South-West Scotland. Where evidence of this disease appeared in milk submitted for examination, producers were advised of appropriate control measures. The milk furnished by individual members of two other Farmers' Co-operative Creameries was examined and reported on. In one case, the management had experienced trade losses because of a disagreeable flavour and lack of keeping properties in the processed milk of the creamery: in the other case, the manufacture of the creamery milk into cheese was unusually difficult.

Bacterial counts of over 100 samples of commercial and grade milks were made and 66 samples tested for butter-fat and solids-not-fat.

Several cases of bad flavours in the milk of farm dairies were found by investigation to be caused by specific bacterial contamination. A persistent burnt flavour in the milk supply of an Ayrshire dairy farmer led to the rejection of the affected milk by the vendor. The methods of production, and the care of the utensils appeared to be satisfactory, but samples of the water taken from the supply tank serving the dairy were found by bacteriological investigation to contain an organism which could produce a similar taint in sterilised milk. The tank was thoroughly cleaned and overhauled and as a consequence the trouble disappeared. Several instances of a faulty flavour in market milk due to bacterial contamination were traced directly to infected utensils and equipment, not of the producers who were blamed by dealers, but of the dealers themselves.

An objectionable oily flavour was found to be present in the milk of individual cows of a dairy farmer whose supply was the subject of complaint by the receiving creamery. The samples were taken direct into sterile glass bottles, thus eliminating the possibility of metallic contamination, which is held to be the common cause of the oily flavour. A complete change of diet was advised and adopted;

the creamery reported the disappearance of the fault. It would appear from this and from other observed experiences, that a faulty flavour suggestive of " oiliness " may often be due to a disturbed metabolic condition in individual cows, and that exposure of the milk with specific metals is not the invariable cause of " oiliness " in milk.

Cheesemaking problems.

Weak body in cheese.—In recent years, increasing numbers of cheesemakers have experienced weakness in the body of the cheese during manufacture, accompanied by an unsatisfactory texture and a sharp acid flavour in the ripe cheese. Recent investigations conducted by this Department have shown that the effect is not due to any specific contamination of the milk during its production or handling, nor commonly to a lack of vigour in the starter culture used by cheesemakers ; but that the fault is inherent in the cheese milk itself, which physically may appear to be quite normal. The alteration in the reaction of the milk is invariably due to udder disturbances (mammitis and kindred infections) in the producing cows, and unless the milk of the affected animals is withheld from the cheese vat, no improvement in the character of the cheese can be effected, even by the most skilled cheesemaker. Additions of chemicals like soluble lime salts, suspended phosphates, or bacterial activators to milk productive of slow-working weak-bodied curds have not effected any improvement in the character of the cheese. Among the biochemical tests which have been found useful in picking out the abnormally reacting milk of the individual cows, are the alizarol and catalase tests, and the rennet test. A modification of the Wisconsin curd test has been used with success in the course of our investigations on this subject.

Putrefaction in cheese.—The obnoxious taint which caused serious economic losses to cheesemakers in the 1928 to 1930 seasons and which did so much damage to the Scottish cheese industry did not recur during 1931 and hitherto has not been reported in the 1932 season's make. The cause of the taint, the probable source of infection and methods of control have been made the subject of previous communications. In view of the fact that rennet is considered to be a vehicle by means of which the taint-producing organisms may be disseminated, a bacteriological examination was made of 25 samples of rennet actually used on individual cheesemaking farms during the 1931 season ; putrefactive bacteria of the type causing the dreaded taint could not be demonstrated in any of the rennets. Even in the years when the taint was rampant, no trace of putrefaction occurred in our control cheese made with commercial rennets.

During the period under review, experiments were carried out to determine whether active strains of *Str. cremoris* and *B. acidophilus*

used as starters could exercise any controlling effect on the development of the taint-producing organisms when the latter were introduced into the cheese milk. It was found that in neither case was the taint prevented; after a period of eight to nine months the experimental cheese developed the obnoxious taint while the control cheese from the same milk and with the same starters, but not receiving the infective material, remained sound. (It may be noted that *B. acidophilus* exerts a definite restraining effect on gas producing bacteria and many other common contaminating organisms found in cheese milk which has not been produced under hygienic conditions.) It was also found that in appropriate cultural media, to which the putrefactive bacteria were added, neither the common lactic acid bacteria nor *B. acidophilus* exerted any restraining effect on the emergence of the taint. It does not appear therefore that control of putrefaction in cheese can be effected by the use of selected starters. Experiments to determine whether associated bacteria—themselves incapable of causing the fault—play any part in the development of the taint, were conducted. There is some evidence that this is the case.

Burnt flavour in cheese curds.—An intensely disagreeable "caramel" or burnt flavour was observed in the cheese curds made from the milk of a farm where good methods of production were practised. The fault continued with undiminished intensity in spite of the exercise of scrupulous care on the part of the dairyman. Systematic examination by this Department showed that the infective organism was a lactic acid coccus, that it was not derived from the water supply or utensils (which were carefully cleaned and steam sterilised after use), or from any specific contamination of the milk due to laxity in methods of production. The udders and flanks of selected cows in the herd were thoroughly washed and disinfected and the foremilk rejected. Samples of the milk were then withdrawn under aseptic conditions into sterilised glass bottles. These samples on incubation developed the characteristic smell observed in the affected cheese curds. From the incubated milk a predominating lactic acid streptococcus was isolated, which could reproduce in sterilised milk and whey the characteristic burnt smell. A pure culture of this organism in sterilised milk was used as a starter in the making of cheese from normal milk, a control cheese being simultaneously made from a portion of the same milk to which a stock starter was added. The experimental cheese containing the isolated organisms in milk culture developed the characteristic burnt smell, while the control cheese remained normal.

This appears to be the first recorded case of an intramammary infection by a lactic acid organism productive of a burnt flavour.

Starter investigations.—With reference to pure culture starters such as are issued by this laboratory for the use of buttermakers and cheesemakers, the following factors have been studied: (i) varia-

tions in the size and shape of colonies on the plate in relationship to vitality in milk culture, (ii) the response of raw and pasteurised milk to the activity of starter organisms, (iii) effect on the vigour of lactic acid bacteria of raw bacterial-free whey from Seitz filtered milk. No definite relationship between size and shape of colony in relation to vigour of cultures developed from them was established. As a general rule, pure cultures of lactic acid bacteria used as starters grow more easily in sterilised than in pasteurised or in fresh raw milk. Seitz filtered milk as a cultural medium did not result in more active cultures than when pasteurised or sterilised milk was used.

The type of milk used in starter making was found to exercise a very definite effect—irrespective of the heat treatment to which the milk is subjected. Some types of milk were found to have a debilitating effect on the vigour of starter cultures. A diagnostic test which will enable one to select milk which is suitable in all respects for starter making is now being sought.

During the past year over 2,500 starter cultures have been issued for the use of the dairy industry.

Buttermaking experiments.—It has recently been shown that starters which have a favourable influence on the development of flavour and aroma in butter are characterised, not only by the lactic acid they produce, but also by a definite production of acetyl-methyl-carbinol. By oxidation this substance becomes converted into diacetyl, the factor which is thought to be mainly responsible for the aroma of good butter. To determine whether a desirable aroma could be impressed on winter-made butter (which is usually lacking in aroma) sweet cream butter was made in December from milk produced under good hygienic conditions. The fresh cream was pasteurised and diacetyl added in regulated amounts (equivalent to 0.0003 per cent.) to the cream before churning and to the butter during working. It was found that a very definite aroma was conferred by the added diacetyl : the aroma, however, was somewhat heavy and resembled that of commercial butter in bulk. The flavour of the treated butter (as determined by these experiments) was not materially improved by the diacetyl treatment. A commercial preparation, containing diacetyl, advocated for use in margarine manufacture, was assessed. Margarine made experimentally in our laboratory, with this preparation added during the course of manufacture, was sensibly improved (as compared with the untreated control) in respect of aroma and flavour.

The problem of improving the aroma of butter is being approached from the biological side, and the isolation of strains of lactic acid bacteria, which by reason of their acetyl-methyl-carbinol production will, when used as starters, enhance both aroma and flavour, is now proceeding.

Effect of specific foods on milk and butter.—In collaboration with the advisory officer in milk production, an enquiry into the effects

of dried beet pulp and of roots (swedes) on the flavour of milk and on the character of the butter produced from such milk was undertaken. It was found that swedes gave a more pronounced colour to milk than beet pulp when those foods formed the succulent part of the basal ration. The flavour and the "quality" of the milk of the root fed cows was also more attractive than that of the beet fed cows.

The most striking difference between the butters made from roots and from beet pulp was the colour. Root feeding imparted to the butter quite a decided tint, which, although lower in tone than that observable during the pasture season, was of a pleasing shade. The feeding of beet pulp provided a dead white butter, entirely devoid of colour, and resembling lard in appearance. In general technical qualities, the butter associated with root feeding was superior to that produced when beet pulp was used. In the latter case, the body and texture were somewhat weaker in character, and on storage the butter became oxidised and tallowy in a relatively short time : the "roots" butter was firmer, more waxy in character and had a greater degree of stability on storage.

The results of these experiments, which extended over a 10 weeks' period, serve to indicate the distinctive effect which the succulent part of the basal ration has on the character of the milk and on the butter made from it.

Cream investigations.—In view of the problems which arise in the sterilisation of cream for market purposes, experimental work in the preparation of this product has been initiated. The production under commercial conditions of a sterilised cream which will have the desirable keeping properties, show no coagulation effect as a result of the processing, and which will not "feather" when added to hot tea or coffee, appears to be difficult of accomplishment. Whether such effects can be overcome, and whether any modification of the processing will enable sterilised cream to be whipped will be the subject of enquiry.

Titles of papers issued during the year.

MILK PRODUCTION.

1. An enquiry into the length of life of dairy cattle. *Ann. Rep. Scott. Milk Rec. Assoc.*, 78–81, 1931.
2. McCandlish, A. C. : A day in Denmark. II. The live stock. *Ayrshire Cattle Soc. J.*, **13**, 4, 141, December, 1931.
3. ———: A day in Denmark. III. Organisation. *Ibid.*, **4**, 1, 31, March, 1932.
4. ———: A day in Denmark. IV. Sanitation. *Ibid.*, **4**, 2, 51, June, 1932.
5. ———: Hoven or bloat in dairy cattle. *Ibid.*, **4**, 3, 98, September, 1932.

MILK UTILISATION.

6. Leitch, R. H.: Dunlop cheese. *Kilmarnock Standard,* November–December, 1931.
7. ———: Cheddar cheese. *Scottish Farmer* Publishing Co., June, 1932.
8. ———: Starters and starter making. *Dumfries and Galloway Standard,* December, 1931.
9. ———: Aroma in butter. Retention in flavour. *Glasgow Herald,* 15th January, 1932.
10. ———: Faults in cheese. *Scott. Farmer,* 20th and 27th February, 1932.
11. ———: Pasteurisation and its applications. *Milk Trade Gaz.,* 26th March and 9th April 1932.
12. ———: Butter and buttermaking. *Scott. Trader,* 12th February, 1932.
13. ———: Flavour in milk. *Scott. J. Agric.,* April and July, 1932.
14. ———: L'arrêt de la fermentation lactique dans la préparation du fromage. Special jubilee volume of *Le Lait,* June, 1932.
15. ———: Acidophilus milk. *Milk Industry,* June, 1932.

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ECONOMICS.

116. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES.

Farm management analysis.—The depression in livestock and livestock produce markets which set in about in the middle of 1931, and which fell in great force on the sheep markets during the autumn of last year, had probably not had its full effects on the farm accounts closed during the year. Yet these accounts showed very much poorer results than those available in previous years. Upon examination it was found that 15 farms failed to yield enough to pay any wages of sons and daughters, and the occupiers failed to earn anything for their own management or capital; seven others failed to yield sufficient to pay full wages to sons and daughters, while nine others failed to yield enough to pay interest on capital at 6 per cent. Only half the farms showed any "labour income," or earnings of labour or management, for the farmer himself.

Milk costs and prices.—A short investigation of the relation between costs and prices of milk has been made. The data obtained show, generally, rising prices with rising costs per gallon, and even though there is a tendency towards higher profits at the lower end of the scale of costs and prices there are many cases in which high costs are necessarily related to the markets in which the higher prices can be realised and are sought.

"Cattle ranching" survey.—Analysis of the records of the survey of farms in Radnorshire has shown that under this system of "cattle ranching," i.e., of raising calves by suckling on cows at pasture, the cost of maintaining a cow is only about £7 12s. per annum against an average of about £22 10s. per annum in the dairy herds of Wales. On the average each 100 cows raise about 104 calves. The conclusion is that this system is connected with the demand for high quality store cattle of the Hereford type, which, apparently, can only be raised from cows of low milk yield capacity. But on the whole the system is rather wasteful of resources and there is no evidence that it has been especially highly profitable in recent years.

Movements of livestock from Brecon and Radnor.—A survey of the movements of cattle, sheep, pigs and horses "exported" from the counties of Brecon and Radnor has been made in completion of this survey for the whole of Wales.

Investigation of prices.—Special attention has been given to prices of feeding stuffs, of pigs, of hides and skins, and to some extent of sheep. Forecasts of prices of feeding stuffs and of pigs have been made from time to time with a fair degree of accuracy and success. The forecasts of prices of feeding stuffs have been sought by representatives of commercial firms of considerable standing in the trade.

Titles of papers issued during the year.

1. Ashby, A. W.: A review of the sheep position in Wales and the outlook in sheep farming. *Welsh Nat. Conf. on breeding and marketing of sheep, Aberystwyth,* November, 1931.

2. Ashby, A. W. : Some notes on adult classes in rural districts. . *Adult Educ.*, **5**, 4, April, 1932.
3. Howell, J. Pryse : Further study of some factors of efficiency in milk production. *Welsh J. Agric.*, **8**, 1932.
4. Davies, J. Llefelys : The marketing of sheep in Wales—1. The draft ewe and store sheep trade—2. The fat lamb trade. *Welsh Nat. Conf. on breeding and marketing of sheep, Aberystwyth*, November, 1931.
5. ———: Labour requirements of crops on Welsh farms. *Welsh J. Agric.*, **8**, 1932.
6. ———: By-products of the cattle industry. *Ibid.*, **8**, 1932.
7. ———: Operation of egg packing stations—(1) A farmers' co-operative station. (2) A private station. (Reproduced for the Ministry of Agriculture.)
8. ———: Rhai agweddau ar safon byw mewn ffermydd cymreig. (Some aspects of the standard of living on Welsh farms.) *Efrydydd*, Bala.
9. Williams, J. Glynne : Changes in the sheep population of Wales. *Welsh J. Agric.*, **8**, 1932.
10. Henderson, R. : Partial protection of the fresh pork market : A study of the effects of the Meat Imports (Prohibition) Order, 1926. (Departmental Circular.)

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11. *GENERAL.*

Reports of Conferences on Development of Agricultural Co-operative Business, Aberystwyth, October, 1931 and May, 1932. (Issued by th Department.)

Papers : A winter programme for agricultural co-operative societies.
The Trend of Prices. (An address based upon the paper, "The prospects of trade in feedstuffs and fertilisers," prepared by Williams, J. Glynne, Henderson, R., and Ashby, A. W.)
The Agricultural Marketing Act, 1931.
Horace Plunkett—A brief sketch of his life and work. Anderson, R. A.
Grinding and mixing balanced rations.
Functions and duties of the committee of a co-operative society.
New developments in co-operative organisation and finance.

12. *FARM AND MARKET.*

3, 2, 1932.
Milk marketing schemes.
Prices of liquid milk in Wales.
Trends in values of dairy herd products.
Some results of co-operative cheese-making.

3, 3, 1932.
The horse trade in Cardiganshire.
A small holding in Anglesey.
The calf trade in Cardiganshire.
Cattle ranching in Radnorshire.

13. *AGRICULTURAL BUSINESS.*

2, 5, 1931.
The price situation and co-operative trading.
The trade in lime of Welsh agricultural societies.

2, 6, 1932.
Co-operative marketing of milk in New York.
The use of home grown and purchased feeds on Welsh farms.

2, 7, 1932.
The egg and poultry industry.
The story of the Co-operative Grange League, U.S.A.
2, 8, 1932.
Production and marketing of eggs in Wales.
Production, price and consumption of eggs.

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117. BRISTOL UNIVERSITY.

Farm costing.—Six farms are costed in detail by the recognised "Oxford" method, which entails the recording of labour employed, feeding stuffs and fertilisers used, and the movements of livestock. The smaller number of cost accounts as compared with that for the previous year is due to the re-organisation of the work which has already been referred to.

Records and costs of experiments in management.—As from the middle of the year under report, a number of farmers have agreed to keep weekly records concerning the management of their dairy herds but since the enquiry must be continued for a complete year, no results can yet be reported. It is anticipated, however, that it will then be possible to furnish useful information relating to variations in management as shown by milk yields in relation to types and quantities of foods consumed, and by the incidence and type of disease.

Financial accounts.—The usual work of collecting, analysing and reporting upon financial accounts has been continued and is regarded as the foundation of the Department's work. For the year under review, 190 farm accounts have been dealt with in this way. Fifty of these were received from members of the Wiltshire Agricultural Accounting Society, and meetings were held at two centres, where the annual tables, which make comparison between the various farms, were freely discussed by the members.

Strawberry production.—In January, 1932, a survey was made of strawberry growing in the Cheddar Valley, Somerset. This was undertaken as a preliminary to the collection of cost account data. A report upon the position of the strawberry growing industry is in course of preparation.

Survey of willow growing industry.—In July, 1932, a survey of the willow growing industry of Somerset was carried out. The area surveyed is a compact one measuring nine miles by seven and the growing of bush willows and the preparation of them for market constitutes the chief source of income for the bulk of the population in this district. The results of the survey are being embodied in a report to be issued by the Department of Agriculture and Horticulture of the University.

Sugar beet production.—The modified scheme of ascertaining the cost of production of sugar beet on 20 farms in Herefordshire and

Worcestershire has been continued. The costs so computed have been communicated to the farmers co-operating.

Titles of papers issued during the year.

1. Dawe, C. V. : Factors affecting Wiltshire profits. *Bristol U. Statistical Series*, 4.
2. ——— : A bulletin for Somerset farmers. *Bristol U. Bull.*, 7 (Part I).

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118. CAMBRIDGE UNIVERSITY.

Economic survey of Eastern Province.—An economic survey of agriculture in the province was commenced in September, 1931. Records covering the complete organisation of each holding were secured from over 1,000 farms chosen at random from the clay, loam, and light soils of the district. A number of the county organisers gave valuable assistance, while the response of farmers was unexpectedly cordial. The primary objective of this enquiry is to secure information relating to the economic position of cereal production in the Eastern Counties. In fact, however, data relating to many other aspects of the economic organisation and financial position of farming in the area were secured. This enquiry is being continued for a further two years, and work for the second year was commenced immediately on completion of that of the first.

Cost of production studies.—The cost of production studies of wheat and sugar beet have been continued, data relating to some 100 fields of the former, and 50 fields of the latter crop being secured. Two further studies of a similar nature covering strawberries and milk respectively have been commenced, the co-operation of approximately 25 farmers having been obtained in each case.

Titles of papers issued during the year.

1. An economic survey of agriculture in the Eastern counties of England. Report No. 19, 1931. *Farm Econ. Br., Dept. Agric., Camb. U.* Price 2*s.* 6*d.* net.
2. *Interpretation of farm accounts.* Farmers' Bulletin No. 1. Price 6*d.*
3. Carslaw, R. McG. : Farming losses in the Eastern counties. *Essex Farmers' J.*, November, 1931.
4. ——— : Re-adjusting farm organisation. *Yorks. Agric. Soc. J.*, 1932.
5. ——— : The dairy enterprise in Hertfordshire. *Herts. Milk Recording Soc. J.*, 1932.

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119. HARPER ADAMS AGRICULTURAL COLLEGE.

Carrot survey.—The acreage costed comprises nearly 50 per cent. of the carrot acreage in the province. Yields generally were lower than in the previous year, and disposal correspondingly easier.

Potato survey.—The acreage surveyed was 680 acres of main-crop varieties on 23 farms in various parts of the province. The most popular varieties were King Edward, Majestic and Great Scot.

Seasonal conditions were poor and yields extremely variable. Financial results were mostly good.

Sugar beet.—Costings were continued on 20 farms with 815 acres of beet. Seasonal conditions were very bad, and both yields and sugar contents were lower than for any previous year of the survey. On the average of the whole acreage a small cash loss was shown, whilst the depression in the sheep trade militated against the profitable utilisation of the beet tops.

Milk.—In connection with the national co-operative scheme of milk costings, arranged by the Advisory Economists Conference, twenty farms in Shropshire are being costed on the enterprise basis.

Poultry survey.—This has now become the major activity of this Department. Some hundred farms in the counties of Shropshire, Staffordshire, Warwickshire, Cheshire and Lancashire have been costed during the year. The adviser for the Northern Province is also co-operating in this survey, and altogether information will be available by the close of the second year from 150 good farms. In the year 1932–1933 Bristol Province will enter the Scheme, whereby the whole of the north and west of England will then be covered, with a total of at least 300 farms.

Titles of papers issued during the year.

1. Dennis, F. S.: Poultry Bulletin (issued monthly).
2. ———: Some results of the economic survey. *Harper Adams Utility Poultry J.*, **17**, 561, 1931-32.

120. LEEDS UNIVERSITY.

Agricultural history.—The survey of the Manor of Hooton Pagnell has now been completed, and is practically ready for publication. It has been interesting and instructive to trace in actual concrete form, among other things:—

(*a*) The variation in the privileges and responsibilities of ownership, as well as the methods by which that ownership was acquired.

(*b*) The gradual enclosure and consolidation of the farm holdings.

(*c*) The variations in the systems of land tenure.

(*d*) The history and development of the rights of the tenant,

and, more especially, to study the many still extant survivals of the old manorial system of farming, and their influence on present-day agriculture.

Miscellaneous.—The following investigations have also now been completed:—

The economics of the production and disposal of peas for picking green, with a special study of the possibilities of expansion of the area under the crop in view of the re-opening of a canning factory; the rise and fall in the flax industry around Selby; the economic

position of the potato crop in Yorkshire ; and a survey of the sheep industry in the county.

It is hoped that opportunities will be found in the near future for writing up for publication the results of these investigations.

The only piece of new work undertaken has been a survey of one of the Dales of Yorkshire—Nidderdale—which arose quite naturally as a result of a recent sheep investigation. An attempt has been made over a narrowly circumscribed area to correlate the method and system of farming adopted with physical, soil, and marketing conditions, and the results obtained have been most promising, and certainly justify an extension of the method into other areas.

Titles of papers issued during the year.

1. Ruston, A. G. : The agricultural depression and the methods by which it is being met. *J. Farmers' Club*, 2, 1932.
2. ———: The county of broad acres. *Yorks. Supp. Financial News*, May, 1932.
3. ———: The pros and cons of grass and arable farming. *J. Land Agents' Soc.*, June, 1932.
4. ———: Agriculture and the national crisis. *Rotarian*, April, 1932.
5. Ruston, A. G., and Liversage, V. : The position of the sheep enterprise. *Proc. Agric. Econ. Soc.*, **2**, 2, June, 1932.

121. MANCHESTER UNIVERSITY.

Feeding for milk production.—A start has been made with a scheme of research in management for milk production in co-operation with economists in other provinces of England. Investigation in previous years confirmed the view that farmers were not using their farms to their full capacity to produce food for their cows and other stock, and that the capital invested in the farms was not giving a full return. After long search and the discarding of one test after another, the question how much a farmer spends on fertilisers, and how much on feeding stuffs, per cow, was chosen. The scheme of co-operative research has proved successful so far in getting the costs of these things per gallon on a considerable number of farms. The character of the work is two-fold. The farmer is moved to demonstrate in his own practice the financial advantage of improving his grass and hay, and the measure of this advantage is obtained from the keeping and analysis of records as full and accurate as possible as well as from ordinary cost accounts. These in turn are used as a guide and stimulus to him and to other farmers similarly situated to carry the experiment further.

Arable crops.—Work on the same principle as the milk production scheme has been carried out with the co-operation of a few arable farmers, particularly with potato growers.

Title of paper issued during the year.

1. Orr, J. : Economy in feeding for milk production. *Manchester U. Press*, 1932.

122. MIDLAND AGRICULTURAL COLLEGE.

Economic survey of farming in North Leicestershire.—This survey has been completed and reports sent to about 75 farmers covering an area of 19,000 acres. A second survey of wold farming was carried out this summer. The field work has already been completed, but, owing to the depression, a number of farmers who were in the first survey were, for various reasons, unable to co-operate in the present survey. The field work on a production and marketing study of potatoes was started at the beginning of 1932 and at the moment over 400 farmers, growing 16,000 acres of potatoes, are in the scheme. Approximately 5,000 acres of main crop and about 400 acres of earlies and second earlies are being costed under this scheme. Statements showing the allocation of costs on this year's crop have already been sent to 63 growers of early potatoes. A scheme of research in management for milk production is also in hand and 18 producers are co-operating in this investigation.

Sugar beet costing.—The Department has a small number of farmers anxious to keep costs on their beet enterprise. Ten growers supplied information for the year 1931–32 and a report was sent to each grower, together with a comparative summary of all the collected costs.

Analysis of costing accounts.—The Department has prepared and issued reports on the farms completely costed and on the farms co-operating in the financial accounts scheme. For the year 1931–32 approximately 60 farmers had their financial accounts analysed.

Miscellaneous.—Other problems dealt with during the past year have included research in management for milk production; potato production and marketing in Lincolnshire and Nottinghamshire; the economics of calf rearing on a Lincolnshire arable farm; second wold survey cost accounts.

Titles of papers issued during the year.

1. Jones, A.: Meat distribution and consumption. *Proc. Agric. Econ. Soc.*, **2**, 1, 1931.
2. Jones, A., and Heath, W. E.: Milk production in Derbyshire. *Derbyshire Farmer*, **12**, 3, 1932.
3. ———: The effect of herd maintenance on milk production costs. *J. Notts Milk Rec. Soc.*, 1932.

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123. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Poultry management study.—The economic study of poultry management, which was begun in December, 1930, in conjunction with the West Midland and North Western advisory provinces, has been continued. The first accounting period (10 months) ended on September 30th, 1931, and for this period it was found possible to

complete accounts for 28 enterprises in the four northern counties. The accounts revealed that, despite adverse economic conditions, particularly in respect of falling egg prices, poultry farming on the whole was capable of yielding a fair return for the investment of capital and managerial skill involved. In individual cases, however, the trading results showed a wide range of variation as between the most and the least successful, indicating that there is a good deal of " slack " to be taken up in many cases. The reports submitted to the co-operators called attention to the noteworthy features of their trading results and, in most cases, it was found possible to offer suggestions which, if adopted, might be expected to lead to improved results. The interest shown in the study has increased, and for the second accounting period it is anticipated that some 40 accounts will be completed. No further extension is being made in the third year now begun.

In addition to the financial accounts and production data, complete records of incubation results from 24 farms were analysed and published in the September, 1932, bulletin.

In view of the importance of the marketing problems of the poultry industry, the question of a comprehensive survey of the existing conditions of the production and sale of eggs in the counties of Durham and Northumberland was taken up with the representative organisations of producers in the area. There are considerable difficulties to be overcome before such a survey can hope to be successful and steps are now being taken to examine ways and means.

Title of paper issued during the year.

1. Dinsdale, D. H.: Economic safeguards for agricultural workers in Great Britain. *L'Assistenza Sociale Agricola*, Rome, August, 1932.

124. READING UNIVERSITY.

Cost accounts. — Complete cost accounts for the whole farming activities were kept on six farms. Four of these farms have been included in this investigation since its commencement eight years ago. All farms are typical representatives of important farming systems, and as such their accumulating records are providing important data on both financial (historical) and farm management problems. A report on the six years' results of one farm has already been published, and a second report on another farm covering a period of eight years has also been prepared for publication.

Enterprise studies.—The keeping of accounts of the beef-producing enterprise on a Hampshire farm, and of the poultry enterprise on three other farms mentioned in last year's report is being continued. In all these cases there are interesting developments in the management of the activities concerned.

Survey of the strawberry industry in Hampshire.—This survey was carried out in co-operation with the Swanwick and District

Fruit Growers' Association, Ltd., and with the Horticultural Superintendent of the Hampshire County Council. The field work was commenced immediately the 1931 crop was marketed and by the end of October every one of the 560 members of the Association had been visited. Although survey records were taken for 482 growers, information sufficiently complete for calculating the costs and returns of the 1931 crop was obtained from 350 growers only. An interim report on the financial results of these 350 growers was prepared at the special request of the Association for discussion at their annual general meeting in December. A final report is now in course of completion, and will be published shortly.

Dairy farming survey.—The preliminary arrangements for the third survey are now being made; this will be a survey of dairy farming in the Vale of Aylesbury.

Financial Accounts.—Twenty farmers (selected after the survey of the Blackmore Vale district) co-operated in this investigation, the first year of which closed at Lady Day 1932. All the farmers kept accounts in books specially designed for their type of farming. The report on this investigation showed that when no charge was made for family labour 15 farms showed 'profits' and five showed losses; when family labour was charged at current wages rates only three farms showed 'profits' and 17 showed losses. The 20 farmers are continuing their co-operation for another year and these farms are also being used for the purpose of the special investigation into certain aspects of economic milk production with which the advisory economists are jointly concerned.

Titles of papers issued during the year.

1. Thomas, E., *et al.*: Financial results of strawberry growing in South Hants, 1931. *Survey Studies* 2. *Bull.* **43**, *Reading U. Agric. Econ. Dept.*, 1932.
2. Bisset, G. B., and Pringle, C.: Effect of reduced milk prices. *Farmer and Stockbreeder*, July 25, 1932.
3. Thomas, E.: Some economic problems of the strawberry industry. *J. Proc. Agric. Econ. Soc.*, **2**, 3, 1932.
4. Thomas, E., Bissett, G. B., and Pringle, C.: Financial results of dairy farming in the Blackmore Vale, 1931–32. *Financial Accounts Studies* 1, *Reading U. Agric. Econ. Dept.*, August, 1932.
5. Thomas, E., and Bisset, G. B.: Hampshire strawberry industry. *Fruit Grower*, October 6, 1932.
6. Bisset, G. B., Pringle, C., and Thomas, K. W. B.: Financial results of strawberry growing in Hampshire in 1932. *Financial Accounts Studies* 2, *Reading U. Agric. Econ. Dept.*, 1932.

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125. SEALE-HAYNE AGRICULTURAL COLLEGE.

Financial accounts.—The main portion of the work of the Economics Department continues to be the analysis of farm accounts. During the year the accounts of 87 farmers were collected, analysed and reported on. Forty-nine of these farmers had their books

closed by the Department. Assistance was given to a further 28 farmers who were commencing to keep books.

An analysis of 15 Mid-Devon farms over the six year period 1925 to 1931 revealed that over that period farms which pursued dairying and/or barley-growing obtained better results than those which relied on livestock for their output.

Labour requirements.—The scope of the investigation into the productive horse and man labour requirements of crops and livestock has been extended to include pigs, poultry and orchards. Twenty-one farmers completed a second year's labour diary.

Strawberry costs.—Costs of growing the maiden strawberry crop have been collected from four growers. The records will be continued.

Movements of livestock in Devon and Cornwall.—This investigation was completed during the year and a report published (1).

Broccoli costs.—The Horticultural Staff of the Devon County Council is interesting Devon farmers in broccoli growing. Several farmers have taken up this crop for the first time this year. Eight of them are keeping records of costs in collaboration with this Department.

Feeding stuffs investigation.—This study, commenced in November, 1931, was continued ; complete records for the year will be obtained from about 33 farmers. In order that the results should not be biased too much by the weather and conditions of one year, it has been decided to continue the study for another year. The second year's study, however, will relate to a smaller number of farms. Probably between 12 and 20 farmers will continue.

Titles of papers issued during the year.

1. MacGregor, J. J.: Movements of livestock in Cornwall and Devon. *Seale-Hayne Coll. Pamph.* 38, July, 1932.
2. Long, W. H.: A study of six years' farming results in Devon. *J. Min. Agric.*, 38, 11, February, 1932.
3. ———: Potato growing in Mid-Devon. *Ibid.*, 38, 12, March, 1932.

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126. WYE : SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Farming costs.—The general investigation into farming costs of production and financial results has been continued. It is now quite clear that although a comparatively small number of farms has been studied many of the conclusions that have emerged are of general application.

Food recording scheme for dairy cows. — This scheme was continued for a third year and has more than justified the hope that the procedure necessary in this scheme would lead to economies in milk production.

Strawberry growing.—An investigation into the economics of strawberry growing was commenced in the summer of 1932 and will be continued in 1933. This is the first systematic study which the department has made of fruit crops and it is already evident that the problems to be solved by the strawberry grower are in a different category from those of the grower of the staple farm crops.

Titles of papers issued during the year.

1. Wyllie, J.: Investigation into farming costs of production and financial results. Hay crops and grazing—1924 to 1931. *S-E.A.C. Dept. of Economics, Rep. No.* 13.
2. ———: The surplus milk problem. *J. Brit. Dairy Farmers' Assoc.*, 14–26, 1932.
3. ———: The economic outlook for agriculture. *Berks. Farmers' Yr. Bk.*, 43–48, 1932.
4. ———: Some aspects of economic milk production. *J. S-E.A.C.*, 9–21, 1932.
5. Wyllie, J., and Hewison, N. V.: Financial results on the College farms. Milk production over five years, 1926–27 to 1930–31. (An example in building up a tuberculin tested herd.) *S-E.A.C. Dept. of Economics, Rep. No.* 14.

127. ABERDEEN: NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Financial accounts investigation.—The investigation into the profitableness of farming in Scotland is being continued and its scope increased. The farmers co-operating are increasing in numbers and the study is extending into new areas. Many farmers are voluntarily joining the accounting scheme and applying for information gained from the general analysis of the accounts.

Each farmer co-operating received a report on his farm along with a general report on the average results obtained from farms of a similar type. The figures showed that the farmers, although slightly more successful than the previous year, were still in a very unsatisfactory position as regards financial returns. The records for the past year are now being analysed.

Winter milk production.—A specialised study of the costs of winter milk production in the area was carried out in the month of December. The results have been distributed to the co-operating farmers and an article has been prepared for publication. A similar study relating to the cost of summer milk is in progress.

Miscellaneous.—The cost accounts have been continued and the poultry investigation has been extended.

Title of paper issued during the year.

1. Imper, A. D.: Cost of growing oats in the North-east of Scotland. *Scott. J. Agric.*, **15**, 1, 75–77, 1932.

128. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Farm accounts investigation.—The collection of records from farms of the border arable-sheep type for the year 1930–31 (covering the crop year 1930) was completed, and the data were analysed. The most noteworthy feature of the year's results was a heavy fall in profits as compared with previous seasons.

An analysis of the financial results suggested that, as in the previous year, (i) profits increased with increased "production" (excess of sales over purchases of the same thing, expressed in money and allowing for valuation changes), (ii) profits decreased as the production of cattle to sheep became greater, (iii) profits decreased as the number of extra store sheep bought for feeding purposes increased, (iv) profits decreased with an increasing proportion of cultivated land, and (v) profits were substantially lower on heavy soil farms than those situated on light or medium soil.

Particularly was it noted that both production and profits, in 1930–31 as compared with 1929–30, fell most heavily on the heavy soil farms.

The mathematical correlation method, used experimentally in respect of the years 1928–29 and 1929–30, although its value undoubtedly suffered from the small size of the groups dealt with, has, in the three years, given results which were consistent and confirmatory of those derived by other methods. By its use it has been possible to calculate for each farm an "estimated profit" which allowed for the influence of major factors in farming policy (e.g., the percentage of land under tillage, the proportion of cattle to sheep, and so forth) and gave a jumping-off point from which to study managerial and other matters peculiar to the farm concerned. The methods used have been indicated in an article which will appear in the Scottish Journal of Agriculture. They are admittedly experimental, but appear worthy of further study.

Smallholdings accounts investigation.—A report, dealing with the year 1930–31 (covering the crop year 1930), was issued in the early summer of 1931 (1).

Ten holdings were included, of which nine showed a profit (averaging £165) and one a loss (£77). In calculating the figures, allowances were made for the use of the house (£10) and for produce consumed (average value £22). Nothing was charged for the occupier's labour or that of his wife, but any other labour was charged. Classifying the ten holdings, the best results were shown by four dairy holdings whose profit averaged £189. The number of holdings was, however, too small for adequate classification.

In interpreting the results, it should be pointed out that the holdings were mainly "Demonstration Smallholdings," chosen, in part at least, as being efficiently managed and receiving special

assistance from the county organisers. Some extension of this study, bringing in more non-demonstration holdings, and increasing the sizes of groups, may be desirable.

Titles of papers issued during the year.

1. WHITTAKER, E.: Report on the financial results of ten smallholdings, 1930–31.
2. ———: Some Factors in Success, No. 3. Border semi-arable sheep farms in 1930–31. Both circulated privately.
3. ———: An experiment in the interpretation of farm profits. *Scott. J. Agric.*, **15**, 3, 302–329, July, 1932.

129. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Financial accounts investigation.—The collection of farm accounting data for inclusion in the " Profitableness of Farming in Scotland " report of the Department of Agriculture for Scotland has been continued during the year. To date, a total of 85 farms are co-operating either directly or through the medium of professional farm accountants. The results will, in due course, appear in the Department's publications. The comments of co-operating farmers are favourable to the accounting scheme and the advisory work carried out.

Miscellaneous.—During the year under review a start has been made on poultry accounting and on the collection of data relating to the costs of feeding in milk production.

From a general viewpoint, the year 1931–1932 has shown a continuance, and in some cases a worsening, of depression conditions. A downward tendency in milk prices has adversely affected dairy farming while an exceedingly poor market for hay has meant a considerable diminution in the volume of receipts on groups of heavy land farms. Last year's low prices for lambs has been followed by another and more marked decline at the sales of this year's crop to the detriment of the sheep farmer.

R.

GRASSLAND.

130. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES (WELSH PLANT BREEDING STATION).

Seeds mixtures.—The work is being continued by resort to large scale trials conducted in the counties. Data have been collected from a large number of trials that have been set up at different dates during the last six years. It is intended to publish a report on all this extensive work at a comparatively early date.

The improvement of rough and hill grazings.—This important work has been much extended. Some details of the work have already been published (1, 2, 3), but a great deal of additional data has been collected during the summer. An interesting feature of the work has been the fact that establishment of wild white clover has been greatly facilitated on some of the areas by inoculation and this is an aspect of the general problem which is being closely followed up.

Titles of papers issued during the year.

1. Stapledon, R. G. : Improvement of rough and hill grazings—I. General Review. *J. Min. Agric.*, **38**, 11, 1109–1113, February, 1932.
2. ———— : Improvement of rough and hill grazings—II. Application of manures supported by heavy grazings. *Ibid.*, **38**, 12, 1215–1222, March, 1932.
3. ———— : Improvement of rough and hill grazings.—III. Sowing seeds, cultivation and manuring. *Ibid.*, **39**, 1, 36–46, April, 1932.

III.

OTHER INVESTIGATIONS.

131. IMPROVED MANAGEMENT OF GRASSLAND.

(*a*) WELSH PLANT BREEDING STATION, ABERYSTWYTH.

The extensive experiments which were set up in 1926 on the Penglais Field have now been completed and have been reported upon in a recent bulletin (1, 2).

These experiments have given valuable evidence on palatability, the reaction of different species and strains to nitrogen, and the behaviour of wild white clover in competition with the various species and strains of grasses.

The marked differences between the chemical composition of leaf and of stem of grasses have again been emphasised. It has been shown that the effect of manure is not necessarily the same on the chemical composition of the leaf as the stem of a grass, and this adds further emphasis to the importance of the ratio stem to leaf in its influence on the nutritive value of herbage. In the case of grasses the stems of which are grazed to a greater extent than is usual (e.g., Italian rye-grass) it is interesting to find that the stems of such grasses contain less fibre than is associated with stem in the generality of cases.

In connection with all these investigations the position taken by white clover in the sward is a matter that has called for further investigation, and a great deal of chemical work has been conducted. The high calcium and protein contents of different strains of white clover have been demonstrated by results which have been reported during the year (3).

The work on the chemical composition of different grass and clover species when grown in competition with each other and in pure plots and when grown on different habitats is proving of the greatest interest, and the work is being extended to cover a still wider range of conditions. A preliminary report on some aspects of this work is now in course of preparation.

Titles of papers issued during the year.

1. Stapledon, R. G., and Milton, W. E. J. : Yield, palatability and other studies on strains of various grass species. *Welsh Plant Breeding Sta. Bull., Series* H. 13, 1–79, October, 1932.
2. Fagan, T. W. : The influence of nitrogenous manures on the chemical composition of the produce of individual grasses as pasture, hay and aftermath. *Ibid.*, 80–92.
3. Williams, R. D., and Evans, T. W. : Chemical composition of various white clovers and of Italian rye-grass. *Welsh J. Agric.*, **8**, 151–162, January, 1932.

(*b*) BRISTOL UNIVERSITY

The field work on the plots in Longleat Park was concluded at the beginning of October, 1931, as the owner was anxious to utilise the experimental area for other purposes. With the concurrence of the Ministry it was arranged to examine, chemically, the large number of herbage samples which had been collected by the resident

recorder during the preceding five years and an assistant chemist was appointed to carry out this work. During this period some 250 grass samples from the plots had been completely analysed. In addition, soil samples from the plots had also been examined and from the results obtained the following conclusions may be drawn :—

(i) That the soil of all plots is deficient in phosphoric acid.
(ii) That the herbage from all the plots is deficient in phosphoric acid—The average content of phosphoric acid in the dry matter being 0.45 per cent.
(iii) That the deficiency of phosphoric acid in the soil and the herbage is a limiting factor and the action of the other fertilisers had been inhibited by this deficiency.
(iv) That the application of nitrogenous fertilisers produces a temporary improvement in the chemical composition of the herbage, but this improvement has disappeared in the course of three months.
(v) That there is an increase in the nitrogen content of the intensively grazed herbage as compared with the extensively grazed herbage during the summer months. In any case the average protein content has never been more than 16.5 per cent. of the dry matter.
(vi) The lime (CaO) content of the herbage is generally high, particularly in relation to the phosphoric acid.

It is hoped to continue certain of these investigations as a part of the grassland research programme of the Department, which has recently been modified as the result of a special grant from the Agricultural Research Council and generous donations from private donors. In this revised scheme, attention is paid to the following :—

(i) The nitrogen metabolism of certain herbage plants.
(ii) The effect of different systems of manuring and management on the chemical composition of grass.
(iii) The effect of season, manuring and management on the lime and phosphoric acid status of herbage.
(iv) The feeding value of winter grass.
(v) The effect of continual cutting and nitrogenous manuring on the botanical and chemical composition of Down herbage ; (for this purpose the plots originally established at the request of the Development Commissioners are being used).
(vi) The comparison between the yield and composition of grass converted into stack silage (with and without chemical treatment) and hay.
(vii) The chemical and botanical composition of grass from the Teart lands of Somerset.

132. PRODUCTION OF SEED POTATOES ON A COMMERCIAL SCALE IN NORTH WALES.

BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

The scheme is at present being conducted at 26 centres situated in different parts of North Wales. Seven of these, after a test of three years, were established in 1930 as suitable for the maintenance and production of seed potatoes relatively free from virus diseases. At all seven, less than .5 per cent. virus infection was again recorded during 1932, so that those centres have continued now for five and six years to maintain an exceptionally high standard of health. At another seven centres, where the test period of three years has just been completed, the amount of virus diseases has not exceeded the .5 per cent. standard and seed stocks of the same high quality are being produced. Fourteen centres, therefore, are now qualified to sell seed potatoes under the conditions of certification adopted by the scheme in 1930. The remaining twelve centres came under the supervision of the scheme for the first time during 1932, but until it can be shown that the standard of .5 per cent. virus disease has been maintained for a period of three years they will not function in the same category as those already mentioned.

The Welsh seed from the 1928 centres and from the seven started in 1930 was compared with Scotch seed in a series of carefully conducted yield trials, the varieties under test being Sharpe's Express, Great Scot, Kerr's Pink and Arran Banner. No significant difference in yield between the three classes of seed was found even in those varieties where the Scotch seed was of the very superior grade known as " Stock Seed." It is concluded, therefore, that the Welsh seed potatoes produced under the conditions of the scheme are in no way inferior to really good stocks of Scotch seed.

In previous years the stocks of seed potatoes certified by the scheme have been marketed under a joint scheme arranged each season by a conference of growers. With the volume of supplies increasing, however, this system was felt to be inadequate and steps were taken towards the formation of an organisation of a more permanent character. Arrangements are at present in progress to form a growers' organisation for the purpose of marketing, but it is unlikely that this will function in time to handle the crop of the present season.

The estimated quantity of seed which is expected to be available is approximately 70 tons ; of which 35 tons is Kerr's Pink, 20 tons Sharpe's Express and 15 tons Great Scot.

133. METHODS OF MECHANICAL ANALYSIS.

BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

The work on mechanical analysis, carried out at the instance of the Imperial Bureau of Soil Science with the aid of a grant from the Empire Marketing Board, covering the period Feb. 16th, 1930, to June 22nd, 1932, has now been completed.

A full report has been sent to the Imperial Bureau of Soil Science. (Published as Technical Communication No. 26, 1933.) The following conclusions have been drawn from the work :—

(*a*) As a result of the examination of 120 representative samples of soil, mainly from overseas, but including a few British soils, it appears that the international method with suitable modifications gives satisfactory dispersion in mechanical analysis.

(*b*) The principal modification consists in the substitution of sodium hydroxide for ammonia as a dispersing agent.

(*c*) The dispersion thus attained is so efficient that the amount of shaking required may be appreciably reduced.

(*d*) The difficulty with gypseous soils may be obviated by :—

(i) removing coarse gypsum after peroxiding and before acid treatment.

(ii) using a stronger acid ; and

(iii) washing with 10 per cent. ammonium acetate.

(*e*) Oxidation of organic matter by hydrogen peroxide appears to be necessary with all soils containing more than about 1 per cent. of organic carbon.

(*f*) By including a preliminary boiling with water, it is possible to secure oxidation with more dilute (2 per cent.) peroxide.

(*g*) Manganese dioxide, which interferes with peroxide attack, may be decomposed by preliminary digestion with water and $NaHSO_3$.

(*h*) Aluminous soils present a special difficulty as they are not dispersible in alkaline solution. Dispersion may be effected in a slightly acid medium.

(*i*) For most soils the proposed modification gives results which agree fairly closely with those by the international (ammonia) method.

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134. STUBBLE CLEANING.

CAMBRIDGE UNIVERSITY.

During 1931–32 the investigation on the efficacy of autumn surface tillage in eradicating weeds involved two large field experiments similar in technique and lay-out to those of the previous year. The influence of different implements and time of cultivation on both the mature plants and buried seeds has been studied in detail.

The results of the year's investigation are in agreement with the results of previous work, and show that stubble cleaning is an important means of controlling weeds by (*a*) destroying mature plants, and (*b*) by influencing the seeds of (i) species which show little or no " natural " dormancy, e.g., self-sown cereals, *Alopecurus agrestis* and *Stellaria media* and (ii) those which have " natural " dormancy with periodicity of germination in autumn, e.g., *Papaver Rhoeas, Galium Aparine, Veronica hederaefolia, V. persica, V. agrestis Myosotis arvensis* and *Alchemilla arvensis*. Seeds which do not respond to stubble cleaning are those of species having " natural " dormancy with periodicity of germination in late winter and spring. Among those are *Bartsia odontites, Polygonum aviculare* and *P. Convolvulus*. The broadshare does efficient work against both mature plants and buried seeds, but is more suitable for light than for heavy land. When dealing with a mixed weed flora the best results are to be obtained by an early broadsharing followed three to six weeks later by cross-cultivation, preferably a second broadsharing. To obtain the greatest benefit, the land should not be ploughed till late December.

Work on chlorates.—This year the work on chlorates has been directed mainly to thorn bushes. Small plants were effectively controlled by root action of the poison, but leaf action proved to be more important in large plants. The bushes were found to be more susceptible to injury in late summer than in spring. Small plants 1½ to 2 feet high were killed by sodium chlorate at the rate of 1 lb. for 32 plants when used either dry or in solution. In late summer plants 4 to 6 feet high were killed by spraying with two pints of 5 per cent. solution. Stronger solution was required in spring.

As a result of last year's work, sodium chlorate has been used for the control of *Agropyrum repens* in Herefordshire. Twelve acres of heavy land which had gone out of cultivation because of couch infestation were treated with 10 per cent. solution applied at the rate of 160 gals. per acre, and the results have been satisfactory.

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135. *SPARTINA TOWNSENDII* (RICE GRASS).

ESSEX COUNTY COUNCIL.

Records show that growth of the older plants continues to be normal after making due allowance for variation in the situations. Attention, therefore, has been concentrated on the younger plantations and on those localities which have previously resisted colonisation.

As regards the younger plantations, observations indicate in practically every case that good cuttings are superior to seedling plants up to one year old. Thus, at Goldhanger in Section 2, the cuttings have taken root at the rate of 84 per cent. and the seedlings 14 per cent.; in Section 3 the figures are 80 per cent. and 30 per cent.

respectively. In the most difficult site of all, Section C at Hadleigh, the best cuttings that could be procured only succeeded at the rate of 1 to 2 per cent. and the seedlings none at all. The Dutch authorities hold a converse view with regard to the value of seedlings.

The sections mentioned in the previous paragraph are those on which it was desired to make a comparison of the speed of the tidal currents, as this factor seemed to be the only one likely to account for the almost complete failure in Section C at Hadleigh.

Preliminary tests carried out on the Goldhanger sections showed that further modifications were necessary in the specially designed tide-measuring instrument. These have now been effected.

In critical situations there is evidence indicating that the time of year at which planting is done may be important. Therefore, in such a situation at Goldhanger a series of lunar monthly plantings was begun in January, 1932, and will be carried on to December, 1932.

Germination tests with seed have been repeated. These confirm previous findings that the period of vitality is relatively short, although in the present year the period was four weeks longer than in 1930–31, viz. 17 weeks as against 13, and that freshly-gathered seed may be expected to have a high rate of germination—80 to 90 per cent. In view of the low rates of germination which have been experienced elsewhere it is pointed out that the samples in question consisted of properly-filled seeds. When collecting seed it is the rule that on any spike there are about as many empty fruits as full ones. In accordance with the usual practice such empty husks were treated as impurities.

An experiment to test various methods of establishing natural seed-beds was laid down at Goldhanger.

The demand for plants from people at home and overseas has continued. Cuttings have been sent to Norfolk, Yorkshire, Ireland, Sarawak, India, Argentine and Australia.

One report of a previous consignment has been received from the Geelong Harbour Commissioners who state that the plants are " bidding fair to become established."

The 24 plants sent to the Riverina District, New South Wales, in 1930, 300 miles from the coast where the soil tends to become too salt for the natural grasses, have also made good headway, and the farmer in question finds that his stock seem delighted with the taste of the plant.

The consignment sent this year to India (Dept. of Agriculture, Punjab) was for a similar purpose.

Titles of papers issued during the year.

1. Oliver, F. W., and Bryce, J. : Further notes on the economic possibilities of Rice Grass. *J. Min. Agric.*, **38**, 8, November, 1931.
2. Oliver, F. W., Bryce, J., and Knowles, F. : *S. Townsendii* (Rice grass), its economic possibilities. *Min. Agric, Misc. Pub.*, 66.

136. BACTERIAL DISEASES OF PLANTS.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

The researches on bacterial plant diseases carried out at the Imperial College under the supervision of Professor Paine have been largely of a diagnostic character the results of which are embodied in special reports to the Ministry's Pathological Laboratory and are not available for publication. Seven investigations of this kind have been undertaken during the year and, although it was not possible always to establish the cause of the disease, negative results gave useful information regarding its cause. Miss Lacey has continued her investigation of the green-fluorescent group of Pseudomonas organisms and has published part II in this series. Bacteria of the green-fluorescent group were found to be the causal agents of a disease of potato tubers, a rot of lettuces and of brown lesions in the seeds of *Medicago lupulina*. The close similarity of the cultural characteristics of 36 strains isolated from various plant lesions and of 32 species of the green-fluorescent group was pointed out, and it was shown that some variation in cultural characters might occur in cultures grown from colonies from a single isolation plate. For example, of two colonies isolated from black-spot of larkspur one produced acid from sucrose, the other did not ; in other cases there was a difference in indol production or in the peptinosation of milk. Considerable variation in fluorescein production occurred throughout the group, broth cultures of pH 7.2—8.2 incubated at 25°-30° C. were found to produce the most fluorescence.

Title of paper issued during the year.

1. Lacey, M. S. : Studies in bacteriosis.—XIX. Researches on the group of green-fluorescent bacteria. Part II. On some plant diseases caused by bacteria of the green-fluorescent group and a comparison and discussion of various cultural characteristics of certain members of this group. *Ann. Appl. Biol.* **19**, 2, 190–203, 1932.

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137. FLUCTUATIONS IN NUMBERS OF WILD RODENTS.

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

An investigation was started into the past fluctuations in the North American fur bearing animals, by examination of the diaries and records in the archives of the Hudson Bay Company.

The work on British rodent populations was continued, the main problem during this period being the spread and distribution of the American grey squirrel in this country, and the economic aspects of its increase in numbers. A considerable amount of time was taken up by advisory work in connection with the campaign against

these animals organised by various agricultural bodies with the co-operation of the Ministry of Agriculture. The work on vole and mouse fluctuations was continued, using quantitative census methods for the elucidation of the apparent four year cycle in numbers. A statistical study of fluctuations in rabbits, hares, and game animals was started, evidence being obtained of the existence of marked fluctuations, with, in many cases, a fairly regular cycle in numbers similar to that found among North American rabbits and game birds. Field studies of an epidemic of coccidiosis among wild rabbits were carried out during the summer, and investigations were made into various outbreaks of disease and parasitism in rabbits, hares, squirrels, etc. An intelligence service of about 1,200 voluntary observers throughout the country was maintained by correspondence and personal contact for providing reports and data on many of the subjects being investigated.

Title of paper issued during the year.

1. Elton, C., Baker, J. R., and Ford, E. B.: The health and parasites of a wild mouse population. *Proc. Zool. Soc., Lond.* Part 3, 657–721, 1931.

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138. INVESTIGATION OF BREEDING SEASONS OF WILD FIELD MICE.

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

Both the observational and the experimental work is now concluded, and the results are being analysed and published as a series of papers in the Proceedings of the Royal Society, B. (1, 2).

It has been shown that the length of the daily period of exposure to light may be a controlling factor in reproduction. When the summer period of exposure to light is given, reproduction may be much reduced by lowering the temperature. Temperature and light appear to be the factors controlling the breeding season. Food seems not to influence it. Mice breed very rapidly when fed upon the food which we regard as their natural winter food, if high temperature and long daily periods of exposure to light are given.

As regards the observational work, supplies of mice were sent to us monthly for two years from Merionethshire, Roxburghshire and Aberdeenshire. Nearly three thousand mice were sent. Each was dissected, carefully examined, and reported upon. The mass of information thus collected is still being analysed. It is clear that *Microtus* has a sharply defined breeding season, unlike certain other species of mice. In the three areas the mice breed for nearly the same length of time (roughly March to September), but those in Roxburghshire tend to have a slightly longer breeding season than

those in the southern and northern areas. Altogether 219 females were caught from Oct., 1930, to Feb., 1931, inclusive. Of these not one was pregnant.

Each autumn last year's mice die off, and only the ones born the same year live over the winter. They remain very small and sexually immature until the following spring.

With some species of mice great fluctuations in numbers might be caused by their breeding fairly fast in some winters and not at all in others. The fluctuations in abundance in *Microtus* cannot be due to this cause.

Titles of papers issued during the year.

1. Baker, J. R., and Ranson, R. M.: Factors affecting the breeding of the field mouse. Part I—Light. *Proc. Roy. Soc.*, B. 110, 313, 1932.
2. ————: Factors affecting the breeding of the field mouse. Part II—Temperature and food. *Ibid.*, B. 112, 39, 1932.

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139. RESEARCH IN ECONOMIC ORNITHOLOGY. (INCLUDING THE OXFORD BIRD CENSUS.)

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

Rooks.—In the area of 910 square miles in which a census of the rookeries was made in the spring of 1931, ten roosts of rooks and jackdaws were located during the winter, and the area from which each drew its population was fairly clearly defined by observing the flights of birds to it at dusk. It is practically certain that no other roosts were situated within the area, but three other roosts were discovered outside the area which drew part of their population from within it. Overlapping of the feeding ranges of the birds from different roosts was noted on several occasions. Counts of the birds have been made at four of the roosts and the numbers agreed well with the known breeding populations of the areas in each case, making it almost certain that the population of rooks in the district is constant throughout the year.

During April assistance was given to Mr. J. F. Wynne, who was making a census of the rookeries in the Isle of Wight. The number of nests counted was 4,200, and the area of the island is 146 square miles. The density—about 29 nests to the square mile—is thus much the same as in the Oxford district. The distribution of the rookeries shows similar phenomena; they are absent from the higher land and the more extensive wooded areas, and are chiefly situated in valleys near streams or close to the coast. The elm is the tree most commonly used, containing 43 per cent. of the nests, oak, Scots pine, ash and beech following in that order. These five species contain 90 per cent. of the nests.

Martins.—A census of the house and sand martins breeding in an area of 56 square miles, including Oxford, was again made in the summer. The population of house martins was found to be 715 pairs in 1932 as against 757 pairs in 1931. In the 12 square miles which included the urban area the population had remained constant, with a density of 27 pairs per square mile; but in the 44 square miles mainly rural there had been a decrease, the density having declined from about 10 to about 9 pairs per square mile. The decline was most marked in the villages furthest from Oxford and was certainly not due to any lack of mud during the building season.

The number of pairs of sand martins could only be roughly estimated. The only large colony in the area was estimated to have decreased from 250 to 150 pairs, whilst elsewhere there was an estimated increase of 20 pairs.

Bird Census.—The results of the counts of all birds present on an area of 125 acres of a farm at Sandford-on-Thames for five winters and three summers have been analysed and published. The average number of birds present in winter was found to be between two and three per acre. There was, however, a steady decline from about four per acre in October to about one-and-a-quarter per acre in March, representing the death or departure of the surplus birds produced in the previous summer. Apart from the species which chiefly visit the area in flocks and feed in the fields, the bird population of the hedgerows and copses was found to be approximately the same in numbers in summer and winter, though the composition of the population was decidedly different at different seasons.

During the winter 1931–32, counts were made seven times on another portion of the farm about equal in area but containing a considerable proportion of arable land. The average number of birds found was about twice as large and there was no apparent decrease in numbers during the season.

In the summer a census of birds breeding on the whole of the farm was undertaken for the fourth time.

An attempt made during the early summer to determine the breeding population of redshanks and snipe in the valleys of the Upper Thames and its tributaries was unsatisfactory owing to the heavy rainfall which twice resulted in the flooding of almost all the breeding areas. A large proportion of these birds abandoned the attempt to breed after the second flood.

Bird marking.—Two trapping stations were again operated in Oxford throughout the two winter terms and a third for a shorter period. At these 861 birds were ringed. In addition, operations with nets, chiefly at roosts, resulted in the capture and ringing of a further 389 birds, making a total of 1,250 adult birds ringed during the winter.

A short visit was paid to the Swiss " Vogelwarte " at Sempach in the early autumn to study the methods of catching birds employed there. Three weeks were afterwards spent at Holy Island, Northumberland, where some of these methods were tried, in addition to various local devices. Unfortunately, for the second autumn in succession there was a great scarcity of migrant birds on the island and comparatively few captures were made.

Titles of papers issued during the year.

1. ALEXANDER, W. B.: The bird population on an Oxfordshire farm. *J. Animal Ecol.*, **1**, 58–64, May, 1932.
2. WYNNE, J. F.: The rookeries of the Isle of Wight. *Ibid.*, **1**, 168–174, November, 1932.
3. ALEXANDER, W. B.: Traps for bird ringing. *Brit. Birds*, **25**, 204, December, 1931.

140. GREY SQUIRREL INVESTIGATION.

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

The numbers of American grey squirrels in this country were much lower in 1931 and 1932 than in 1929 and 1930, a great reduction occurring in 1930–31 winter owing to outbreaks of disease. A general campaign has been waged against them in 1931 and 1932 with the effect of still further reducing their numbers in certain areas. But the extension of range has continued in spite of the low numbers, so that the grey squirrel now occurs over an area of approximately 18,000 square miles in the British Isles. In 1932 a slight increase over the numbers of 1931 occurred, and the stock appears to be free from disease ; there is, therefore, every reason to anticipate a period of increase from the present time onwards. The female grey squirrels normally have only one litter in a season, the litters averaging four young. Young squirrels do not breed until the midsummer following the year of their birth. The grey squirrel has remarkably few internal parasites, with the exception of coccidia ; it appears, however, to be very susceptible to coccidiosis.

Title of paper issued during the year.

MIDDLETON, A. D.: The grey squirrel (*Sciurus carolinensis*) in the British Isles, 1930–1932. *J. Animal Ecol.* **1**, 2, 166, 1932.

141. TRIALS OF HARDY FRUITS FOR COMMERCIAL PURPOSES.

ROYAL HORTICULTURAL SOCIETY AND MINISTRY OF AGRICULTURE.

At the central station, at the Royal Horticultural Society's Gardens, Wisley, approximately 22 acres are now occupied by the trials of varieties of all kinds of hardy fruits, and in addition some

14 acres are occupied by the collection of varieties maintained by the Society for the purpose of comparison and synonymy. There are 314 varieties of fruit undergoing trial, omitting 32 varieties that have been eliminated, and of this total 50 varieties have been selected for extended trial at the sub-stations, at Long Ashton, East Malling, Ellbridge (Cornwall), Osgodby (Yorks), Emneth (Norfolk), Houghall (Durham), Perdiswell (Worcester), and Wisbech. The stations at Merton and Cambridge are discontinued and a station at the Kent Farm Institute, Borden, for Cherries only, is being established. In an illustrated report of the trials in the R.H.S. Journal (1), September 1932, are set out the results obtained at Wisley and at the sub-stations, descriptions of varieties, tabulated records of cropping of black currants and raspberries at all stations and the suitability of varieties for canning.

Titles of papers issued during the year.

1. Trials of hardy fruits for commercial purposes. *Roy. Hort. Soc. J.*, **57**, 2, 246–284, September, 1932.
2. Rawes, A. N.: New varieties of fruit. *Reading U. Bull.*, **41**, 131–139, 1931.
3. Forsyth, A. G.: Strawberries at Wisley. *Gard. Chron.*, **92**, 2377, 48, July, 1932.
4. ————: Raspberries at Wisley. *Ibid.*, **92**, 2380, 101, August, 1932.
5. ————: Blackcurrants at Wisley. *Ibid.*, **92**, 2381, 129, August, 1932.

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142. PLANT BREEDING WORK ON BROCCOLI.

SEALE-HAYNE AGRICULTURAL COLLEGE.

In the 1931–32 season 50 pedigree stocks, four mass selections and 13 commercial strains of winter cauliflowers were included in trials. The trials were upon 1½ acres at the College and at four centres in Cornwall and three in Devonshire.

Three main weaknesses were found in the commercial stocks tested :—

(1) Commercial Roscoff stocks termed " Early " and " Late " respectively were very commonly not true to description.
(2) The number of days over which " cutting " proceeded was excessively prolonged in early and mid-season varieties.
(3) Very great variation in the type and quality of produce occurred in almost every strain whilst in two cases entire substitution of a non-Roscoff stock was found.

Five pedigree stocks have been produced in which the date of heaviest cutting offers a complete series for commercial purposes from December until April. The percentage of Grade I heads is much higher in these stocks than in commercial varieties tested, whilst the uniformity of maturity is satisfactory except in one stock. This is the first season since the work commenced that stocks covering the whole period of maturity desired, have been obtained.

Uniformity of maturity in winter cauliflowers was found to be complex genetically as in many cases in-breeding of selected plants gave a wider range of maturity dates than the original stocks from which these plants were selected. Pedigree selection appears to offer the only solution to this problem within two generations of plant breeding work.

Four commercial d'Angers varieties under trial were found to be more true to their stated maturity period than Roscoffs, and gave fairly high quality produce. Their very high susceptibility to ring spot (*Mycosphaerella brassicola*) was noted and this caused great deterioration of the crop at two centres. This susceptibility appears to explain the so-called lack of vigour of d'Angers stocks in Cornwall.

A further series of hybrids was obtained during 1931–32 and it is hoped to isolate resistant forms from crosses between pedigree Roscoff and selected d'Angers plants with wide acclimatisation abilities.

The four mass selections tested were found to be much less promising than parallel pedigree stocks, and the same technique of individual hand pollination is being followed on an increased acreage.

Title of paper issued during the year.

Report on trials of pedigree stocks, mass selections and commercial varieties of Roscoff broccoli 1931-32. Seale-Hayne Coll. (Typescript.)

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143. EFFICACY OF CHLORATES AS WEED KILLERS.

NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Both sodium and potassium chlorates have been used in the experiments under review, but only sodium chlorate has been used in later trials. The chemical is much more readily applied in solution (water) and is also more efficacious as a weed eradicator in this form. The concentration of the solution does not appear to matter seriously, water being merely a vector. The guide to efficacy against a particular weed is the number of pounds of the dry chemical applied per acre. Contrary to what might be expected, winter or rather autumn applications are most effective. The autumn application has also the advantage of not interfering seriously with the rotation, since the soil is ready for normal cropping in spring, if application be made not too late. It was found that applications should be made about September, or, failing that, as early in October as possible. Later applications are not recommended if it is desired to crop the soil in spring. Turnips are particularly susceptible to residual effects of late application ; potatoes and cereals are much more tolerant. The efficacy of the chlorate is much enhanced in the case of perennial weeds, if the soil be previously ploughed. For small areas a watering

can is a satisfactory device for application. A potato sprayer with slight adjustment could be readily adapted for larger areas. The following weeds have been successfully eradicated by autumn application as indicated in parentheses :—

Common chickweed (20 lbs. per acre), groundsel (40 lbs. per acre), buttercups (50 lbs. per acre), nettles (100 lbs. per acre), colts-foot (100-120 lbs. per acre), comfrey (120 lbs. per acre), wild chervil (150 lbs. per acre), couch (150 lbs. per acre), creeping thistle (200 lbs. per acre).

Many other weeds of importance are being studied.

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144. BRACKEN INVESTIGATION.

GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Work on this investigation is being carried on so far as the available resources permit. A considerable amount of information has been obtained on the effects of temperature, draining, manuring, etc., on the disease problem, and it is hoped that the detailed account of this work will be ready for publication shortly. In co-operation with the Zoology Department, work was undertaken on some of the insects which prey on bracken. A study was made of the insects of the bracken at Garelochhead.

Investigations have also been undertaken into the use of sodium chlorate as a herbicide, both at Garelochhead and elsewhere.

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145. BACTERIAL FLORA IN COWS' MILK.

GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Bacterial content of milk.—An investigation of the plating method for estimating the number of bacteria in milk was carried out, the bacterial content of a large number of samples being determined by means of series of 20 parallel plates.

In the case of samples whose bacterial content was less than 5,000 organisms per c.c., there was close agreement between the parallel plate counts, the standard deviation being on the average 500 (*i.e.*, five colonies on the 1 : 100 dilution plates). Such a deviation is not high from the biological standpoint and represents a variation in bacterial counts which is of no practical significance in milk analysis. On the other hand, in 51 per cent. of the samples, whose bacterial content was 5,000 and more, there was great variation between the parallel plate counts, the co-efficients of variation exceeding 24.4 per cent.

Taking the mean of 20 parallel plate counts as standard, results of duplicate plate counts were misleading in 21 per cent. of the

samples, whereas those of five parallel plate counts were misleading in only 4 per cent. By using five parallel plates for each dilution, more reliable results can, therefore, be obtained.

An investigation was also carried out to determine whether satisfactory results could be obtained using a simpler method and less apparatus than that used for the official method. The following method fully met the requirements :—

The 1 : 10 and 1 : 1,000 dilutions were omitted. The 1: 100 dilution was prepared by adding 1 c.c. of milk to 99 c.cs. of sterile water. Five parallel plates were poured for the 1 : 100 dilution and two plates for the 1 : 1,000, 1 : 10 c.c. of the 1 : 100 dilution being used as the inoculation for the 1 : 1,000 plate.

This method entails the use of one more petriplate than the official one but requires less other apparatus. It is much simpler than the official method and as five parallel plates are used for the 1 : 100 dilution it gives more reliable results.

The effect of different conditions on the reliability of such bacterial estimates has also been investigated.

Occurrence and significance of coliform bacteria in milk.—Of 21,571 samples tested by the Department in recent years — 48.3 per cent. of the samples did not contain coliform germs in 1 : 10 c.c.; 21.4 per cent. contained them in 1 : 10 c.c. but not in 1 : 100 and 1 : 1,000 c.c. ; 14 per cent. contained them in 1 : 10 and 1 : 100 but not in 1 : 1,000 c.c. ; and 16.3 per cent. contained them in 1 : 10, 1 : 100 and 1 : 1,000 c.c.

The proportion of samples containing coliform bacteria was lower in winter than in summer. This seasonal variation appeared chiefly to be due to atmospheric temperature, there being a marked co-relation between graphs showing the proportion of coliform positive samples and mean atmospheric temperature.

360 coliform strains were isolated from samples of milk received during the months of December, 1930, to April, 1931, and a further 450 strains from samples of milk received between June and November, 1931.

Of these strains 800 have been identified. This work has no been completed but it would appear that a high proportion of the strains identified belong to those types which are the common coliform organisms of the intestines.

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146. STRINGHALT, SHIVERING AND ALLIED CONDITIONS IN THE HORSE.

ROYAL (DICK) VETERINARY COLLEGE, EDINBURGH.

Ten horses have been examined during the period under review, nine of which were subjected to a minute post-mortem examination of bones and joints, and microscopic preparations have been made from numerous tissues.

The horses examined were chosen and destroyed for the following clinical reasons :—shivering, 3 ; partial paraplegia (jinked back), 3 ; hemiplegia, 1 ; stringhalt and navicular disease, 1 ; broken wind, 1 ; healthy pony for comparative purposes, 1.

The further information obtained concerning the chronic disabling conditions which affect the horse would appear to imply that the majority of the conditions scheduled under the Horse Breeding Act (Scotland) 1919, are merely localised manifestations of a general disease.

A visit to the Orkney and Shetland Islands to study the incidence of disease among Shetland ponies confirmed previous information concerning this breed. Under natural conditions Shetland ponies are singularly free from all the so-called hereditary diseases, and also there appears to be a complete absence of diseases associated with pregnancy and the post-parturient state.

Here appear to be equines as free from disease as it is possible to find in Scotland, and in view of the probability that the various diseased conditions under investigation may be due, to some extent at least, to the artificial nature of the diet—oats and hay—it may be possible at a later date to put this hypothesis to experimental proof by using such ponies.

Up to the present attention has been chiefly devoted to the pathological changes occurring in the body of horses rendered useless for work by some localised clinical lesion. The evidence obtained will be added to as opportunity permits, but the mass of material, both naked-eye and microscopic, already collected requires much time and thought to correlate.

In order to appreciate the extent of the problem some statistical figures of the wide-spread nature of unsoundness in horses are required, and it is intended to subject to an examination for soundness a large number of city horses and a corresponding number of country horses (say 100 of each).

Title of paper issued during the year.

1. Mitchell, W. M. : Chronic arthritis in equines. *Proc. Brit. Med. Assoc.*, June, 1932.

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147. INFLUENCE OF FEEDING ON THE COMPOSITION OF THE BLOOD AND MILK OF DAIRY COWS.

DR. J. F. TOCHER.

The effect on the composition of milk of varying the rations to cows has been continued throughout the year. The chemical constituents and physical characters of the blood and the milk of these cows have been determined. Special attention has been paid

to variations in the composition of the milk of a small herd of cows whose milk is consistently low in the proportion of solids-not-fat. The physical characteristics of the milk are being specially studied with a view to determining the range of the osmotic pressure of the milk and its relation to the osmotic pressure of the blood.

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148. STATISTICAL EXAMINATION OF EXISTING DATA REGARDING VARIATIONS IN THE COMPOSITION OF MILK.

DR. J. F. TOCHER.

The analysis of the data sent in to the Ministry of Agriculture from various centres in England and Scotland has now been completed. The results show the nature of the variations in butter fat and solids-not-fat in the milk of individual cows throughout the country. Comparisons have also been made of the differences in the composition of the milk in various areas and breeds.

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149. WORM INFESTATION OF SHEEP.

NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Worm diseases of farm stock.—Much time has been spent on research into the incidence of stomach and intestinal worms of sheep in the College area. Twenty-two sheep from various sources have been autopsied and the fourth stomach and intestines examined for the presence of helminths. It may be safely said that stomach worm disease in lambs is one of the most important economic problems in sheep farming at the present day. The disease is invariably present on farms where the pastures are tending to become foul through overcrowding. Some idea of the high degree of infection frequently met with can be seen in one case where a lamb showing typical signs of worm infestation yielded approximately 5,000 worms in the fourth stomach, 980 in the small intestine, and 38 in the large intestine. There were nine different species of worms present.

The lesser stomach worm (*Ostertagia circumcinta*), a small worm about an inch in length and the thickness of a strand of fine silk, is by far the most important parasite. Unfortunately it does not lend itself to successful treatment with drugs, and the only method of control seems to be one of prevention by rotational grazing, i.e., shifting the lambs on to fresh ground as often as possible. A brief account of the life-history of the parasite will enable one to understand the principle of this control measure.

While attached to the lining of the stomach the female worms produce large numbers of eggs which are passed out on to the grass in the droppings. In from one to two days each egg hatches into a larva which must complete the next two stages of its development on the ground, before it is capable of infecting the sheep when swallowed. The time taken to reach the infective stage may vary between three days and several weeks, the exact time depending upon climatic conditions. Adequate moisture and warm weather are favourable to their development.

In the North of Scotland development would very seldom be hindered through lack of moisture, and it has been stated for this country in general that "it can only be in our warmest weather that they reach the infective stage in less than 10 days." Theoretically, therefore, by shifting lambs on to clean pasture every 10 days during the summer months, infection should be reduced to a minimum.

Little experimental work has been done to test the efficacy of this method, and it was necessary to carry out a test under exact conditions before advocating control measures along these lines. As the Rowett Institute was working on intestinal infestation from the point of view of nutrition, it was arranged to carry out a joint investigation at the Duthie Experimental Farm, which is providing all the facilities for the following investigations:—

Control of stomach worms by rotational grazings.—A three-acre field of third-year grass, which had never carried sheep, was divided into two equal portions.

Six Blackface ewes and their twin Greyface lambs, one month old, were put into one half of the field on 25th May, 1932, and allowed to graze over the whole 1½ acres up to 28th August, 1932.

An equal number of ewes and lambs were allowed to graze only one tenth of the other half at periods of ten-day intervals, except the first period, which occupied five days.

The lambs were autopsied on the 28th August and the contents of the fourth stomach carefully collected and preserved for examination. At the moment of writing the examinations are not completed, but the result of the experiment will be published in the near future.

The influence of the nutritional state of the sheep on its susceptibility to infestation with parasitic worms.—Many workers are of the opinion that nutritional factors exercise an important influence on the degree of infestation of sheep to stomach worms.

Observations in Kenya by workers from the Rowett Institute indicate that improved nutrition renders the sheep more resistant to infestation, and other work on rats supports this view. Recently, Foster and Cort have proved by experiment that the acquired resistance of dogs to hookworms (*Ancylostoma caninum*) may be removed by feeding them on deficient diet, and as quickly restored by an adequate diet.

Advantage was taken of the facilities offered at the Institute to carry out the following joint investigation on this subject :—

Thirty-two parasite-free lambs (reared in confinement on cows' milk, sawdust being used as bedding) were divided into two equal groups. One group received a highly nutritious ration of silage plus linseed and crushed oats, the other received silage only. In August an obvious clinical difference was obtained in the two groups. All the lambs are now being subjected to a natural infection by grazing them for a period of six weeks on pastures known to be infected. At the end of this period the sheep will be autopsied and a careful count made of the worms found in the fourth stomach.

Should a well-fed sheep possess a higher degree of resistance to stomach worms than an ill-fed one there ought to be a relatively small count in the well-fed group.

APPENDIX.

LIST OF DIRECTORS OF RESEARCH INSTITUTES AND HEADS OF ADVISORY CENTRES.

I. RESEARCH INSTITUTES.

A. Soils, Plant Nutrition and Plant Physiology.

Sir E. J. Russell, O.B.E., D.Sc., F.R.S.
Rothamsted Experimental Station, Harpenden, Herts.

W. O. Ogg, M.A., B.Sc., Ph.D.
Macaulay Institute for Soil Research, Craigiebuckler, Aberdeenshire.

R. G. Baskett, Esq., M.Sc., A.I.C.
Chemical and Animal Nutrition Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

Prof. V. H. Blackman, Sc.D., F.R.S.
Research Institute of Plant Physiology, Imperial College of Science and Technology, South Kensington, S.W.7.

B. Plant Breeding, Crop Varieties and Seeds.

Sir R. H. Biffen, M.A., F.R.S.
Plant Breeding Institute, School of Agriculture, Cambridge.

Prof. R. G. Stapledon, C.B.E., M.A.
Welsh Plant Breeding Station, Agricultural Buildings, Alexandra Road, Aberystwyth.

W. Robb, Esq., N.D.A., F.R.S.E.
Scottish Society for Research in Plant Breeding, Craigs House, Corstorphine, Edinburgh, 12.

Ian W. Seaton, Esq., B.Sc.
Plant Breeding Division, Ministry of Agriculture for Northern Ireland, Stormont, Strandtown, Belfast.

W. H. Parker, Esq., M.C., M.A.
National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

T. Anderson, Esq., M.A., B.Sc.
Seed Testing and Plant Registration Station, Department of Agriculture for Scotland, East Craigs, Craigs Road, Corstorphine, Edinburgh, 12.

R. Rae, Esq., B.Agr., C.D.A.
Crop and Animal Husbandry Division, Ministry of Agriculture for Northern Ireland, Agricultural Research Institute, Hillsborough, Co. Down.

C. Horticulture and Glasshouse Crops.

Prof. B. T. P. Barker, M.A.
Agricultural and Horticultural Research Station, Long Ashton, Bristol.

R. G. Hatton, Esq., M.A.
East Malling Research Station, East Malling, Kent.

D. Boyes, Esq., M.A.
Horticultural Research Station, School of Agriculture, Cambridge.

W. F. Bewley, Esq., D.Sc.
Experimental and Research Station, Cheshunt, Herts.

Sir A. D. Hall, K.C.B., F.R.S.
John Innes Horticultural Institution, Mostyn Road, Merton, S.W. 19.

D. Entomology and Plant Pathology.

J. C. F. Fryer, Esq., O.B.E., M.A.
Plant Pathological Laboratory, Milton Road, Harpenden, Herts.

R. N. Salaman, Esq., M.D.
Potato Virus Department, Plant Breeding Institute, Cambridge.

Prof. J. W. Munro, M.A., D.Sc.
Biological Field Station, Slough, Bucks.

Mrs. N. L. Alcock, F.L.S.
Plant Pathological Laboratory, Department of Agriculture for Sootland, Royal Botanic Gardens, Edinburgh, 14.

S. P. Mercer, Esq., B.Sc., N.D.A.
Seed Testing and Plant Diseases Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

E. Agricultural Parasitology.

Prof. R. T. Leiper, M.D., D.Sc., F.R.S.
Institute of Agricultural Parasitology, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.

The Lecturer in Helminthology.
Department of Helminthology, Department of Zoology, The University, Edinburgh, 9.

F. Animal Pathology.

F. C. Minett, Esq., D.Sc., M.R.C.V.S.
Research Institute in Animal Pathology, Royal Veterinary College, Camden Town, N.W.1.

Prof. J. B. Buxton, M.A., F.R.C.V.S., D.V.H.
Institute of Animal Pathology, Cambridge University.

W. H. Andrews, Esq., D.Sc., M.R.C.V.S.
Veterinary Laboratory, Ministry of Agriculture and Fisheries, New Haw, Weybridge, Surrey.

Prof. J. Russell Greig, Ph.D., M.R.C.V.S.
Animal Diseases Research Association, Moredun Institute, Gilmerton, Midlothian.

H. G. Lamont, Esq., M.Sc., M.R.C.V.S.
Animal Diseases Division, Ministry of Agriculture for Northern Ireland, Stormont, Strandtown, Belfast.

G. Animal Nutrition and Breeding.

F. H. A. Marshall, Esq., Sc.D., F.R.S.
Animal Nutrition Institute, School of Agriculture, Cambridge.

J. B. Orr, Esq., D.S.O., M.C., M.A., M.D., D.Sc, F.R.S.
Rowett Research Institute, Bucksburn, Aberdeen.

R. G. Baskett, Esq., M.Sc., A.I.C.
Chemical and Animal Nutrition Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

C. Crowther, Esq., M.A., Ph.D.
Pig Husbandry Experiment Station, Harper Adams Agricultural College, Newport, Salop.

R. M. Wilson, Esq., B.Sc.
Pig Husbandry Experiment Station, South-Eastern Agricultural College, Wye, Kent.

R. T. Parkhurst, Esq., M.Sc.
National Institute of Poultry Husbandry, Harper Adams Agricultural College, Newport, Salop.

Prof. R. C. Punnett, M.A., F.R.S.
Small Animal Breeding Research Institute, Whittingehame Lodge, Cambridge.

Prof. F. A. E. Crew, M.D., D.Sc., Ph.D., F.R.S.E.
Institute of Animal Genetics, King's Buildings, West Mains Road, Edinburgh, 9.

R. Rae, Esq., B.Agr., C.D.A.
Crop and Animal Husbandry Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

H. Dairying.

Prof. H. D. Kay, O.B.E., Ph.D., D.Sc.
National Institute for Research in Dairying, Shinfield, nr. Reading.

N. C. Wright, Esq., M. A., Ph.D.
Hannah Dairy Research Institute, Kirkhill, Ayr.

H. G. Lamont, Esq., M.Sc., M.R.C.V.S.
Dairy Bacteriology Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

I. Agricultural Economics.

C. S. Orwin, Esq., M.A.
Agricultural Economics Research Institute, Parks Road, Oxford.

J. S. King, Esq., Ph.D, B.Sc.
Farm Economics Department, Department of Agriculture for Scotland, York Buildings, Queen Street, Edinburgh, 2.

D. A. E. Harkness, Esq., M.A.
Agricultural Economics Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

J. Preservation and Transport.

Sir W. B. Hardy, M.A., LL.D., F.R.S.
Low Temperature Research Station, Cambridge.

F. Hirst, Esq., M.Sc., A.R.C.S. (Resident Director).
Fruit and Vegetable Preservation Research Station, Chipping Campden, Glos.

K. Agricultural Engineering.

H. J. Denham, Esq., M.A., D.Sc.
Institute of Agricultural Engineering, 37a, St. Giles, Oxford.

II. ADVISORY CENTRES.

Prof. J. A. Hanley, Ph.D., A.R.C.S.
Armstrong College, Newcastle-on-Tyne.

Prof. B. T. P. Barker, M.A.
Agricultural and Horticultural Research Station, Long Ashton, Bristol.

Prof. F. L. Engledow, M.A.
School of Agriculture, Cambridge.

C. Crowther, Esq., M.A., Ph.D.
Harper Adams Agricultural College, Newport, Salop;

Prof. N. M. Comber, D.Sc., A.R.C.S., F.I.S. (Acting Head).
Department of Agriculture, The University, Leeds,

J. Orr, Esq., M.A.
Victoria University, Manchester.

Prof. S. H. Gaiger, F.R.C.V.S.
The University, Liverpool.

T. Milburn, Esq., Ph.D.
Midland Agricultural College, Sutton Bonington, Loughborough.

Prof. H. A. D. Neville, M.A., B.Sc., F.I.C.
The University, Reading.

W. Henderson Hogg, Esq.
Seale-Hayne Agricultural College, Newton Abbot, Devon.

R.M. Wilson, Esq., B.Sc.
South Eastern Agricultural College, Wye, Kent.

Prof. J. J. Griffith, B.Sc.
Agricultural Department, University College of Wales, Alexandra Road, Aberystwyth.

Prof. R. G. White, M.Sc.
Department of Agriculture, University College of North Wales, Memorial Buildings, Bangor.

Principal J. F. Rees, M.A., M. Com.
University College of South Wales and Monmouthshire, Cathays Park, Cardiff.

Prof. J. Hendrick, B.Sc., F.I.C.
North of Scotland College of Agriculture, Marischal College, Aberdeen.

E. Shearer, Esq., M.A., B.Sc.
Edinburgh and East of Scotland College of Agriculture, 13, George Square, Edinburgh, 18.

W. G. R. Paterson, Esq., B.Sc., N.D.A.
West of Scotland Agricultural College, 6, Blythswood Square, Glasgow.

III. OTHER CENTRES OF INVESTIGATION.

The Principal.
East Anglian Institute of Agriculture, Chelmsford.

Prof. E. S. Goodrich, M.A., D.Sc., F.R.S.
Department of Zoology and Comparative Anatomy, University Museum, Oxford.

R. L. Harrow, Esq.
Royal Horticultural Society's Gardens, Wisley, Ripley, Surrey.

W. B. Mercer, Esq., B.Sc.
Cheshire School of Agriculture, Reaseheath, Nantwich.

O. C. Bradley, Esq. M.D., D.Sc., M.R.C.V.S.
Royal (Dick) Veterinary College, Edinburgh.

J. F. Tocher, Esq., D.Sc.
The University, Aberdeen.

INDEX.

PAGE

Abortion :
Bacillary, of ewes .. 174, 321
Contagious, of cattle 176, 320, 321
Absorption processes in farm animals 187
Acarine disease of bees 274, 288
Accounting 59, 234, 343, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355
Agglutination tests 320
Ammonium bicarbonate as fertiliser 259
Anaerobic bacilli .. 332, 333
Anaerobic infections .. 164,319
Anaplasmosis 170
Angular leaf spot of cotton .. 14

Aphis :
Potato 137, 273
Woolly .. 74, 102, 109

Apple blossom weevil 111
Apply sawfly 74, 110
Apple tortrix 111

Apples :
Artificial irrigation 93
Bark, chemical examination 102
Bark ringing 66
Biennial bearing .. 65, 89
Breeding 91
Chemical composition 31, 65
Cover crops 66
Diseases and pests 68, 69, 72, 73, 74, 75, 76, 102, 103, 106, 107, 108, 109, 110, 111, 146, 147, 274, 275, 279, 294, 296, 301, 303, 304, 306
Double working 89
Fruit thinning .. 83, 90
Immunity, causes of .. 102
Leaf relations 100
Manuring .. 66, 67, 91, 146
Marketing 93
Pot cultures .. 66, 81
Pruning 66, 90
Ripening processes 31
Rootstocks 63, 64, 85, 86, 91, 92
Scion and stock 64, 65, 86, 92, 102
Shaping 66
Shoot growth 101
Sterility 130
Storage experiments 31, 69, 82
Variety trials 91
Vitamin content, effect of orchard factors on .. 84

PAGE

Arthritis :
Bovine 318
Ascariasis in pigs .. 151, 318
Ash analysis 102
Asparagus 294
Asters 295, 299
Atlas, agricultural 234
Ayrshire :
Soil Survey of 269

Babesiasis 170
Bacillary white diarrhoea 176, 315, 320
Bacillus chauvoie 321
Bacon 183, 239
B.C.G. vaccination of calves .. 318
Bacterial blight of walnuts .. 107
Bacterial content of milk 325, 326, 330, 374
Bacterial diseases :
Fruit trees 103
Plants 14, 108, 367
B. welchii, classification 164, 313
Barley :
Breeding 37, 47
Diseases 297, 302
Mineral deficiency 29
Manurial factors 30
Nitrogen content .. 11, 12
Variety trials .. 52, 53
Basic slag 9, 10, 259
Basket willow, diseases and pests 296
Battery brooder experiments 196
Beans :
Breeding 116
Canning 116
Diseases .. 265, 295, 304
Bees :
Acarine disease .. 274, 288
Internal economy of the hive 19
Swarming 19
Beet pigmy beetle 278
Beet pulp, molassed 180, 216, 260
Biennial bearing of apples 65, 89
" Big bud " in black currants .. 277
Biological engineering 239, 240
Bird census 370
Bird marking 370
Black arm disease of cotton .. 14
Blackberries :
Breeding 72
Canning 241
Diseases and pests 105, 111, 112
Variety trials 97

PAGE

Black blotch of delphiniums 296
Blackhead disease of turkeys.. 168
Blackleg of mangolds 264, 305
Blight :
Celery.. 300
Potato 305
Walnut 107
Blood :
Composition in relation to milk secretion 225, 227, 376
Effect of feeding mineral supplements 167
Study of, in cattle and sheep 187
Blood Tumours in the fowl 166, 315
" Blue blotch " blackberries .. 105
Bog reclamation .. 58, 59
Bracken :
Diseases 141
Eradication 374
Poisoning 318
" Branch blister," apples .. 106
Brassicae, diseases and pests 121, 122, 146, 293, 300, 305
Braxy in sheep .. 174, 313
Broccoli :
Breeding 117, 372
Variety trials 372
Bronchitis, verminous, in cattle 172
Broncho-pneumonia in sheep 315
Brown rot :
Fruit trees 103
Roses 296
Brussels sprouts :
Breeding 117
Club-root 122
Bulb diseases and pests 110, 135, 264, 283, 284, 285, 304, 305
Bulb fly 285
Bull recording 184
Bunt in wheat .. 293, 305
Butter :
Discoloration 221
Flavour 338
Lipase in 216
" Starter," use of 338
Taints 325
Butter-fat :
Glyceride structure 215
Inheritance 213
Byturus tomentosus 73, 111, 274, 275, 283

Cabbages :
Breeding 118
Diseases and pests 147, 273, 277, 278, 288
Calorimetry 180

PAGE

Calves :
Diseases 164, 314
Feeding .. 189, 213, 233
Poisoning 317
Rearing 208, 333
Vaccination with B.C.G. .. 318
Young beef 208
Cane spot of raspberries and loganberries 105
Canker :
Bacterial 103
Parsnips 119, 295
Roses 296, 299
Canning :
Corrosion 239, 242
Fruit 70, 241
Peas 120, 241
Sterilisation 242
Variety trials .. 116, 120
Vegetables 241, 243
Capsid bugs :
Apples 72, 112, 147, 274
Chrysanthemums 287
Currants 274, 275
Pears 72, 73
Plums.. 73
Carabid beetles :
Strawberries 72
Carrot growing survey .. 346
Carrot fly 123, 147, 276, 277, 278
Cat, parasites 157
Cattle (*See also under* Calves, Dairy Cows):
Blood, study of 225
Cow and bull wastage .. 185
Diseases and pests 161, 162, 164, 165, 169, 170, 171, 172, 174, 175, 176, 224, 225, 228, 314, 316, 317, 318, 320, 321, 327, 328, 333
Effect of light on breeding.. 184
Feeding 213, 227
Inheritance studies .. 184, 201
Plant poisoning 318
Young beef .. 189, 208

Cauliflower :
Breeding 117
Diseases and pests .. 124, 301
Celery :
Breeding 118
Diseases and pests .. 279, 300
Cereals :
Failure in spring 261
Fusarium diseases 302
Seed-borne diseases .. 301
Winter, after-effect of temperature 31

PAGE

Cheese :
Mites 261
Nitrogen Metabolism .. 220
Oxidation-reduction potential 220
Putrefaction 336
Red or rusty spot 220
Ripening 217, 220
Stilton 220
" Starters " 217, 337
Taint 337
Weak body 336

Cherries :
Canning 241
Pruning 90
Rootstocks for acid and sweet varieties 87
Sterility 130
Variety trials 372

Chicken rearing .. 191, 197
Chicory 258
Chlorates as weed killers 144, 256, 308, 365, 373
Chlorotic disease of hops .. 306

Chrysanthemums :
Diseases and Pests 128, 274, 284, 287
Roots as manure 125

Cider 78, 79
Clonal races :
Small fruits 71, 97
Clover :
Diseases 293
Trials 52
Red :
Genetical problems 42, 43
New strains 42, 43
White :
New strains 43
Inoculation .. 12, 359

Club-root, brassicae 121, 122, 298, 300
Coccidiosis of fowls .. 316, 321
Cocoa :
Insect infestation .. 139
Fungal infection 139
Cod-liver oil 181, 189
Collembola 273
Colorado beetle 135
Contagious abortion :
Cattle .. 170, 314, 320
Sheep 164
Contagious pustular dermatitis 164, 314, 320, 321
Cost accounting. (*See* Accounting.)

PAGE

Costs of production :
Broccoli 352
Carrots 346
Farming .. 343, 345, 352
Flax 347
Milk 343, 347, 348
Peas 347
Potatoes .. 346, 348, 349
Poultry 347, 349
Strawberries .. 345, 346, 352
Sugar beet 345, 346, 347, 349
Wheat 346

Cotton :
Angular leaf spot 14
Growing 29

Cream .. 230, 325, 330, 339
Crook in lambs 317
Crop drying 59
Crop improvement 52
Crop yield and the interaction of factors 29
Crown gall 102
Cucumber root flies 127
Cucumbers 126, 127, 128, 295
Curing :
Bacon 239
Walnuts 96

Currants :
Black :
Breeding 72, 98, 277
Diseases and pests 72, 75, 147, 274, 275, 277
Pruning 71
Variety trials 96
Red :
Breeding 99
Diseases and pests .. 286
Classification 71
Pruning 71
Variety trials 96

Dairy by-products, disposal .. 220
Dairy Cows (*See also under* Cattle and Milk) :
Average life 185
Breeding .. 184, 228, 334
Inheritance studies 184, 201, 213
Lactation studies 217, 226, 227
Lactation tetany 171, 174, 225, 314
Mastitis, effect on milk yield 162
Milk fever 175, 225
Nutrition 227
Tuberculosis 228
Verminous bronchitis 184, 228
" Wastage " .. 185, 214, 228

PAGE

Dairy farms, condition of water supplies 330
Dairying industry 233
Deficiency disease of sheep .. 265
Delphiniums 296
Dermatitis 164, 314, 320
Derris 18, 19, 73, 113, 274, 275
Die-back :
Apples 75, 294
Plums.. 74
Diet :
Influence on composition of blood 186, 190
Influence on parasite infestation 189
Influence on susceptibility to disease .. 186, 188, 190
Dogs, parasites 378
Downy mildew of hops 114, 306
Drainage. (*See* Land Drainage.)
Draining, mole 250
Drills, seed 248
Drying, grain 250
Ducks :
Diseases 172
Effect of castration 184
Eggs 195, 327
Genetics of plumage colour 184, 199, 201
Table duck experiments .. 195
Dynamometers 247

Economics :
Agricultural depression .. 233
Agriculture in Scotland .. 234
Dairying industry .. 235
Eelworms :
Chrysanthemums .. 274, 283
Ferns 282
Narcissus .. 264, 284, 285
Peas and beans 295
Potatoes 55, 154, 258, 264, 273, 276, 279, 280, 281, 286, 310
Stem and bulb .. 279, 284
Strawberries 286
Tomatoes 277, 279
Eggs :
Keeping qualities .. 209, 327
Production 189
Quality studies 196
Statistical studies 197
Electricity in agriculture .. 250
Electro-culture 30
Epithelioma contagiosum 163, 172
Ethylene oxide as fumigant 138, 139, 140

PAGE

Farm management surveys :
Dairy industry .. 233, 351
General 343, 345, 346, 348, 349, 350
Feeding :
Beet Pulp for cattle 180, 216, 334
Dried separated milk for calves 213
Economic studies 352
Effect on blood composition 190, 376
Effect on fleeces .. 180, 190
Effect on milk quality 338, 376
Effect on milk yield 218, 227, 333, 348
Influence on susceptibility to disease .. 186, 188, 190
Mineral supplements 187, 191, 192
Oil cakes and extracted meals 189, 193
Pigs 180, 181, 189, 193, 194
Poultry .. 181, 192, 196
Ferns 282
Ferrets 182
Fertilisers :
Ammonium bicarbonate .. 259
Influence on pastures .. 13
Nitrogenous, effect of .. 268
Field mice, breeding seasons .. 368
" Finger-and-toe " disease 146, 264, 293, 299, 300, 301, 305, 306
Flax :
Diseases 145
Straw yield 52
Variety trials 52
Flea beetles .. 155, 275, 284
Fleece, kemp in 203
Fodder analysis 217
Foliage, effects of leaching .. 69
Foot-and-mouth disease .. 169
Foot rot :
Asters.. 295
Barley 302
Oats 302
Peas 295
Tomatoes 302
Forest tree diseases 147
Fowl paralysis 172, 176, 316
Fowl pox 163, 172
Fowl typhoid 165, 172
Freesia disease 296
Freezing of fruit and meat .. 239
Frit fly in oats 283

PAGE

Fruit :
Chemistry .. 69, 70, 77, 83
Physiology 78
Plot layout 99
Preservation .. 78, 241
Products 79, 80
Storage 239, 240
Thinning, apples .. 83, 90
Thinning, plums 90
Trials 371
Fruit rot :
Apple 101
Pear 76
Strawberries 294
" Fruit Russeting," apples .. 106
Fruit soils, surveys 70, 93, 263, 266
Fruit trees :
Artificial irrigation .. 93
Double working 89
Manuring .. 66, 67, 91, 146
Methods of sampling .. 100
Red spider 74, 108, 127, 147, 273, 276
Technique of recording .. 100
Winter washes 147, 276, 278
Fumigants .. 138, 139, 140
Fungi :
Brown rot 103
Grey mould 108
Plant diseases 14
Willows 81, 318
Fungicides (*See also under* Spraying) :
Sulphur 77, 265
Trials 76, 106, 295, 307
Fusarium diseases of cereals .. 302

Gall midges of willows .. 18
Gall mites 110, 111
Gapeworms 151
Gas gangrene in sheep 321
Gastritis, verminous, in sheep 171
Geese 196
Gherkins 118
Gooseberries :
Classification 71
Fruit thinning 99
Variety trials 67, 71
Goats :
Parasites 151
Grain cleaning 250
Grain drying 250
Grass disease of horses .. 175
Grasses :
Breeding .. 40, 41, 48
Chemistry .. 179, 262, 361

PAGE

Grasses—contd.
Experiments 52, 143, 297
Indigenous strains .. 45, 144
Mineral content 179
Nutritive value 43, 257, 361
Ultra Violet Ray Test .. 143
Yield 262
Grassland, experiments 43, 45, 58, 257, 258, 260, 297, 361, 362
Management 13
Grazing :
Hill, improvement 12, 307, 359
Influence on pasture .. 179
Rotational 378
Trials .. 43, 179, 180
Greenhouse white fly 277
Grey leaf disease of oats 259, 300

Halibut oil 188
Hardwood cuttings :
Rooting, conditions favouring 100
Harvester-thresher 248
Hay :
Manuring with basic slag .. 259
Haymaking 248
Heather 269
Helminth infestations of insect pests 154, 155
Helminth parasites :
Bulbs .. 264, 284, 285
Cats 157
Dogs 378
Goats 151
Horses 168
Peas and Beans .. 279, 295
Pigs 151
Plants 153
Poultry .. 151, 152, 321
Potatoes 55, 154, 258, 264, 273, 276, 279, 280, 281, 286, 301
Rabbits 152, 368
Rats and mice 152, 153, 378
Sheep 151, 156, 189, 190, 314, 321, 377, 378, 379
Squirrels 368
Strawberries 286
Tomatoes 277, 279
Wild birds 151

History, agricultural 347

Hops :
Cultural trials 113
Diseases .. 114, 296, 306
Manurial experiments .. 113
New seedlings .. 113, 114
Varieties 114

PAGE

Horses :
Clydesdale breed 202
Diseases and pests 168, 175, 289, 375, 376
Fertility and reproduction in mare 183
Pregnancy 183
Hoven in dairy cattle 334
Human dietetics 188
Hyoscyamus 15, 17

Ice cream, bacteriological examination 330
Insecticides (*See also under* Spraying) :
Derris 18, 19, 73, 113, 274
Pyrethrum 18, 73, 274, 286, 287
Synthetic 265, 287
Insects :
Control methods 274, 275, 276 277, 278, 279, 280
Helminth infestations 154, 155, 156
Intestinal absorption 187
Intestinal worms, (*See under* Helminth parasites.) :
Iodine values .. 181, 182, 187
Ions, movement in soil .. 24
Iris diseases 305
Irrigation 93

Johne's disease 314, 316, 318, 321
Johnin test .. 165, 314, 318

Kale, marrow-stem 264
Kemp in fleece 203

Lactation .. 217, 226, 227
Lactation tetany 171, 174, 225, 314
Lambs, diseases .. 313, 317
Land drainage :
Craibstone drain gauges .. 27
General 59
Nitrogen lost in manuring 9, 27
Lawns, improvement of .. 24
Leaching :
Defoliation effects 69
Lead arsenate 275
Leaf mould, tomatoes .. 125
Leaf relations, apple trees .. 100
Leaf roll, potatoes 294
Leaf scorch, apples .. 88, 89

Leaf spot :
Barley 302
Blackcurrants 75
Cotton 14
Iris 305
Lettuce 295

PAGE

Leaf spot—contd.
Oats 302
Strawberries 294
Turnips 299
Leaf stripe, oats 309
Leafy gall, chrysanthemums .. 128
Leather rot, strawberries .. 146
Leeks, white tip 142, 295, 304
Lettuce :
Diseases 123, 295, 301, 305
Trials 118, 127
Leukaemia in poultry .. 316
Lilac diseases 108
Lime, toxic effect 264
Liming 24, 28, 257, 262, 263, 267
Liver fluke in sheep .. 277, 313
Liver rot 313
Livestock, price movements 234, 343
Loganberries :
Clonal races 97
Diseases and pests 73, 105, 111, 112, 274, 275, 283
Variety trials 98
Louping-ill 174, 319
Lucerne :
Breeding 43, 297
Experiments .. 265, 332
Inoculation 12
Trials 52, 53

Machinery :
Cultivation 249
Haymaking 248
Milking 214
Spraying 249
Testing 214, 251
Maize meal 180
Manganese deficiency, oats .. 259
Mangolds :
Diseases and pests .. 264, 305
Manure :
Horn 23, 24
Manuring :
Artificial fertilisers 9
Experiments 28, 68, 125, 126
Fruit trees 68, 91
Green 9
Market garden crops 258, 263
Nitrogen lost by drainage 9, 27
Pastures, influence on 13, 258
Pot culture of hops .. 113
Violets 265
Mares :
Pregnancy 183
Reproduction 183
Sterility 164
Marketing of produce 93, 236, 334

PAGE

Marmalade 80
Marsh disease 315
Martins, census 370
Mastitis 161, 162, 318, 327, 328
Meat :
  Cold storage 239
  Investigations 239
  Measurement of carcases .. 183
Mechanised farms .. 9, 247
Melampsora of willows .. 81
Metabolism 16, 30, 49, 166, 167, 180
Metallic contamination of milk 216
Mice :
  Field, breeding seasons .. 368
  Fluctuation in numbers .. 368
  Genetics 368
  Parasites 153
Midge, pea 124
Mildew :
  Apple 93, 106
  Clover .. 293, 301, 304
  Downy, of hops .. 114, 306
  Lettuce 301
  Powdery, of cucumber .. 128
  Tomato 300
Milk (*See also under* Dairy Cows) :
  Bacterial content 325, 326, 330, 374
  Blood composition, effect of 225
  Butter-fat content .. 327, 335
  Cleanliness of milk churns .. 327
  Composition 193, 209, 225, 261, 269, 377
  Contamination 216
  Costs 343, 347
  Disposal of by-products .. 220
  Dried separated 213
  Drying and condensing .. 229
  Feeding, influence of 189, 194, 218, 227, 241, 338, 348
  Inheritance studies 201
  Keeping quality 223
  Nutritive value 217
  Pasteurised .. 222, 330, 334
  Production 209, 335, 348, 353
  Purification of effluents from factories 14
  Rapid souring 325
  Ropiness .. 325, 326, 330
  Solids-not-fat 213, 215, 263, 329, 335
  Sterilised 326
  Taints 216, 222, 261, 328, 331, 334, 335
  Typical English 215
  Vitamin content 218

PAGE

Milking hand 330
Milking machinery :
  Speed of milking, measurement 214
  Tests 214
Milk secretion :
  Biochemical aspects .. 227
  Blood composition, effect of 225, 227
  External condition, effect of 225
Mineral content of grasses .. 179
Mineral oils, spraying 76, 109, 276
Mineral supplements in rations 187, 329
Mint rust 295, 302
Mites :
  Blackberry 111
  Blackcurrants 277
  Cheese 281
  Gall 110, 111
  Strawberry 286
Mitscherlich pot experiments 23, 28
Molassed Beet Pulp 180, 216, 260, 334
Mole draining 250
Mosaic :
  Cucumber 295
  Freesia 296
  Hop 306
  Peas 295
  Potatoes 136
  Raspberry 104, 112
  Vegetable Marrow 295
" Moss illness " in ewes .. 317
Moths :
  Ephestia 138
  Phycitid 139
  Plodia 138
  Potato 135
  Selenia 130
Mushroom pests .. 282, 287

Naphthalene 276, 277, 278
Narcissus, diseases and pests 110, 264, 283, 284, 285, 305
Nematode worms (*See also under* Helminth parasites) :
  Metabolism of sheep, effect on 166
Nettle, control 144
Nicotine .. 74, 274, 275
Nutrition. (*See* Feeding.)

Oats :
  General :
    Breeding 46, 47
    Diseases and pests 145, 153, 259, 260, 283, 297, 300, 302, 309

PAGE

Oats—contd.
Manganese deficiency .. 259
Variety trials .. 52, 58
Spring :
Breeding 36
Varieties 54
Winter :
Breeding 36
White oats 39
Yield trials .. 52, 53
Onions :
Breeding 118
Diseases and pests 121, 122, 123, 124, 277, 278, 295
Ornithology :
Martins 370
Rooks.. .. .. 281, 369

Paraffin washes 73, 76, 275
Parsnips, breeding 119
Parsnips, diseases .. 119, 295
Parsley 124
Pastures :
Eradication of poisonous weeds 168
Grazing influence 179
Manurial influence 13, 255, 269, 308
Mineral content .. 255, 257
Nutritional aspects .. 179
Wool production 190
Peaches, rootstocks 87
Pears :
Breeding 72, 86
Diseases and pests 72, 73, 107, 266, 307
Double-working 89
Non-setting of blossom .. 89
Pruning 90
Rootstocks 86
Peas :
Breeding 38, 119
Canning 120, 241
Diseases and pests .. 124, 295
Variety trials .. 52, 53
Peat 25, 26, 45
Perry 80
Petroleum oils 273
Pheasants, diseases 172
Phytophthora disease of tulips 304
Pigeon pox 163
Pigs :
Diseases and pests 151, 171, 318
Feeding 180, 181, 189, 193, 194
Measurement of surface area 183
Mineral requirements 181, 193
Poisoning 319

PAGE

Pinealectomy 200
Pink rot of potatoes 145
Plants :
Genetics 129, 130
Parasites of 152
Ploughing 247
Plums :
Breeding 72
Canning 241
Diseases and pests 73, 74, 88, 103, 275
Rootstocks 63, 87
Sterility 130
Vegetative propagation 87, 100
Thinning 90
Poisoning :
Greenhouse plants 261
Stock .. 166, 168, 317, 318, 319
Potatoes :
Breeding 47
Diseases and pests 50, 55, 58, 123, 135, 136, 137, 144, 145, 154, 258, 260, 264, 273, 279, 280, 281, 286, 294, 300, 305, 310
Identification by chemical tests 268
Manurial treatment .. 259
Metabolism 49
pH determination 260
Registration scheme 48, 57
Seed potatoes, commercial production.. .. 299, 363
Skin spot investigation .. 58
Storage 268
Survey 347
Synonyms 56
Trials :
Quality 11, 48, 55
Spraying 145
Variety 268
Yield and maturity .. 55
Tubers, disinfection of .. 144
Wart disease, immunity trials 14, 48, 55, 56, 57
Poultry :
Anaesthetics, use of .. 173
Battery brooder experiments 196
Calorimetry 180
Cambar breed 182
Chicken rearing 191
Cost of production 247
Diseases and pests 151, 152, 163, 165, 166, 172, 176, 315, 316, 317, 319, 320, 321
Egg production .. 189, 196
Fattening 196, 197

PAGE

Poultry—contd.
Genetics .. 182, 195, 200
Inbreeding 198
Laying experiments .. 192
Management 349
Manure 251, 257
Minerals in diet 189, 192, 196
Nutrition .. 181, 188, 191
Rate of growth .. 182, 189
Sex analysis .. 199, 200
Sex reversal 200
Table poultry 198
Pregnancy diseases in ewes .. 313
Price movements in livestock 234, 343
Protein :
Fattening of poultry .. 182
Milk production 333
Pruning :
Apples 66, 90
Cherries 90
Currants 71
Pears 90
Pyobacillosis, sheep 165
Pyrethrum :
As an insecticide 73
Breeding 135
Products 77
Toxicity 18

Quince, rootstocks 86

Rabbits :
Angora 205
Black Dutch 205
Breeding 204
Chinchilla, types of 205
Earlier matings 204
Helminth parasites .. 152, 368
Inbreeding 183
Pigmentation 205
Rex 205
Spermatozoa, studies .. 184

Raspberries :
Breeding 72, 99
Canning 70, 80
Diseases and pests 73, 75, 104, 105, 111, 112, 274, 275, 283
Manuring trials .. 67, 98
Variety trials 71

Rats :
Experiments with fluorine .. 187
Lactation studies .. 218, 219
Parasites 152, 378
Refection 218
Reclamation :
Bog 58, 59
Tidal mud, by rice grass 308, 365

PAGE

" Red plant " strawberries .. 75
Red or rusty spot, cheese .. 220
Red spider :
Fruit tree 74, 147
Tomatoes 127
Redwater 316
" Refection " 218
Rennet 217
Reproduction, physiology :
Ewes 182, 183, 204
Mares 183
Rabbits 183, 205
" Reversion," black currants 72
Rice grass 308, 365
" Ring spot " 295
Rodents, fluctuating incidence 367
Rooks 281
Root crops, cultivation .. 249
Root development 88
Root flies 127, 147, 277, 278, 282, 288
Rootstocks :
Apples .. 63, 64, 85, 86, 91
Cherries 87
Peaches 87
Pears 86
Plums 63, 87
Propagation 87
Quince 86
Resistance to woolly aphis 102, 109
Walnuts 94
Roses, diseases 146, 296, 297, 299
Rot :
Onions 123
Potatoes 145
Strawberries 146
Roundworms. (*See* Helminth parasites.)
Russeting, fruit 106
Rust :
Mint 295, 302
Wheat .. 35, 298, 299, 303
Willows 296
Rye-grass :
Breeding 40, 44
Feeding value 44
Ultra-violet light test .. 143

Sainfoin 38, 52, 297
Salmonella infection :
Calves 164
Ducks 172
Sawflies .. 74, 110, 274, 275, 280
Scab, apples and pears 75, 107, 146, 267, 275, 296, 303, 306, 307
Scion and stock 64, 65, 86, 92, 102

PAGE

Scrapie 174
Seakale 263
Seed-borne diseases .. 142, 301
Seed drills 248
Seedlings, establishment 44, 48
Seeds :
Disinfection .. 145, 146, 293, 301
Growing 54
Mixtures .. 44, 259, 308
Production 44
Testing 54
Sheep :
Blood, study .. 167, 190
Diseases and pests 151, 156, 164, 165, 173, 174, 188, 189, 265, 273, 277, 313, 314, 315, 317, 319, 320, 321, 377, 378, 379
Deaths of in-lamb ewes .. 318
Economics of sheep production.. 355
Genetics :
Inheritance of deformity 204
Inheritance of face colour 203
Inheritance of wool quality 203
Grazing trials .. 43, 44
Growth and development of mutton qualities 183
Kemp in fleece 203
Mineral deficiency 24, 190, 320
Mineral supplements, effect of feeding .. 167, 190, 192
Nutrition 183
Physiology of reproduction 183, 204
Physiology of wool growth 190, 203
Pigmentation of fleece .. 203
Pyobacillosis 165
Sheep maggot fly 273
Shetland ponies :
Composition of mares' milk 202
Diseases 376
Shivering in horses 375
Sickness :
Peas 295
Potatoes 260, 300
Silage 24, 189, 215, 217, 255, 257
Slugs, control 289
Soils :
Acidity 258, 267
" Carr " soils.. 260
Colours 270
Fertility and mechanisation 9
Liming 24, 28, 256, 257, 262, 263, 264, 267, 364
Manurial Requirements .. 267
Mechanical analysis 256, 364
Mineral content .. 24, 26, 30

PAGE

Soils—contd.
Moisture experiments .. 82
Movement of ions 24
Scottish drift soil 26
Sterilisation 123
Surveys 25, 26, 256, 257, 258, 263, 265, 266, 269
Soya beans 298
Spahlinger anti-tuberculosis vaccine 176
Spartina Townsendii .. 308, 365
Spermatozoa studies 184
" Spikes " of hops 114
" Spotted wilt " of tomatoes 129, 137
Spraying (*See also under* Fungicides and insecticides) :
Apple capsid bug 112
Apple mildew .. 93, 106
Apple sawfly .. 74, 110
Apple scab 76, 106, 275, 303
Blackcurrant gall mite .. 147
Blackcurrant leaf spot .. 75
Bulb fly 285
Cane spot, raspberry and loganberry 105
Celery blight 300
Chemistry 121
Chlorates 144, 256
Corrosive sublimate 277, 278
Combined sprays for summer use 76
Currant capsid .. 275, 286
Downy mildew of hops .. 114
Glyceride oils 265
Lead arsenate preparations 275
Lilac bacteriosis 108
Melampsora of willows .. 81
Naphthalene 277, 278, 279
Nettle, annual 144
Nicotine 128
Pear scab 76, 107, 266
Petroleum oils 73, 76, 273, 275
Raspberry and loganberry beetle 73
Red spider 74, 108, 127, 147, 273, 276
Roses 146
Spreaders 107, 265
Strawberry tarsonemid mite 110
Tar-distillate washes .. 276
Tar oils 273
Tomato mildew 300
Walnut bacterial blight .. 107
Winter trials 147, 276, 278
Woolly aphis.. .. 74, 275

PAGE

Squirrels :
Grey 371
Parasites in 368
" Starters " 217, 337
Sterility :
Apples 130
Cherries 130
Mares 164
Plums.. 130
Stilton cheese 220, 221
Storage :
Bacon.. 239
Fruit 31, 69, 81, 82
Potatoes 268
Walnuts 96
Straw :
Conversion into manure .. 13
Strawberries :
Breeding .. 70, 99, 120
Canning 239, 241
Chemical examination .. 67
Clonal races 71, 97
Costs of production 345, 346, 352
Diseases and pests 72, 75, 105, 110, 111, 121, 122, 142, 146, 264, 265, 283, 285, 286, 294
Pruning 97
Soil conditions, influence .. 264
Training 97
Trials 68, 97
Strawberry bud weevil 264, 283
Strawberry " leather rot " .. 146
Strawberry tarsonemid mite 110
Strawberry " yellow-edge " disease 105, 111
" Streak " disease in potatoes.. 136
" Strike " in lambs 313
Stringhalt in horses 375
Stripe of narcissi .. 283, 285
" Struck " in sheep 321
Stubble cleaning 364
" Sudden wilt " of strawberries 75, 121, 122
Sugar beet :
Breeding 37, 38
Costs of production 347, 349
Cultivation 11
Diseases and pests 278
Nutritional requirements .. 259
Purification of effluents from factories 13, 14
Sugar content 11
Variety trials .. 52, 53
Yield trials 48
Summer pneumonia in sheep .. 315

PAGE

Surveys :
Aerial 263
Agricultural history .. 247
Cattle ranching 343
Farm management 343, 345, 346, 348, 349, 350
Fruit soils 70, 93, 263, 266
Industrial 348
Mechanisation 251
Milk production .. 233, 351
Pest control 281
Willow growing 345
" Sway-back " in sheep .. 315
Swedes :
Breeding 49
Diseases 293, 300
Swine fever 171
Swingback in lambs 320
Syngamiasis 171

Tar oils 273
Tarsonemid mite of strawberries 110
Tetany, lactation 171, 174, 225, 314
Thrips 124, 128, 137
Tick, louping-ill 174
" Tick-borne-fever " 173
Timothy 48
Tobacco infestation 140
Tomatoes :
Automatic oil-fired boiler .. 125
Chemical composition .. 260
Cultivation 125
Diseases and pests 127, 129, 137, 274, 277, 279, 300, 302
Leachings, composition .. 126
Liming 125
Manurial trials 125
Nitrogenous fertilisers .. 125
Physiology 31
Steaming 274
Temperature investigations 31
" Trembling " of ewes .. 317
Tractors 247
Tuberculosis :
Avian .. 171, 316, 319
B.C.G. vaccination .. 171, 318
Bovine .. 165, 171, 224
Dairy cows 228
Spahlinger vaccine 176
Tuberculin 165, 319
Tulips, diseases.. 304
Tung-oil meal 189
Turkeys :
Blackhead disease 168
Genetics of plumage colour.. 200
Intensive rearing 195
Production 195

PAGE

Turnips :
Diseases 293, 299
Genetics 49

Ultra-violet light test on rye-grass 143

Vaccination :
Braxy.. 174
Contagious abortion .. 320
Fowl pox and pigeon pox 165, 172
Fowl typhoid 172
Louping-ill 174
Spahlinger 176
Vegetables :
Canning 243
Cold storage .. 239, 240
Preservation 240
Virus diseases :
Artificial feeding of aphids .. 17
Aucuba mosaic .. 16, 129
Experiments with *N. Glutinosa* 16
Filterable viruses 15, 163, 332
Hops 306
Hyoscyamus .. 15, 17
Insect transmission .. 112, 137
Metabolism of infected plants 16
Potatoes 17, 18, 50, 51, 56, 57, 135, 136, 294
Raspberry mosaic .. 104, 112
Relation to host plant .. 16
Relation to insect-vectors .. 137
Tomatoes 16, 129
Weeds 16
Violets 265, 285
Vitamins :
A., deficiency 318
B., " refection " 218
Chemical estimation of Vitamin A 219
Content of fish oils 188
Content of milk 218
" C " requirements of dogs.. 166

Wales :
Soil survey of 256
Walnuts :
Curing and storage .. 96
Diseases and pests .. 107, 108
Grafting 95
Oil content of nuts .. 96
Pollination 95
Propagation, indoor and outdoor methods 94

PAGE

Walnuts—contd.
Rootstocks, layering .. 94
Varieties 95
Warble fly, control .. 274, 277
Wart disease, immunity trials 14, 48, 55, 56, 57
Waterfowl production .. 195
Weeds :
Control by stubble cleaning.. 365
Edible, chemical composition 255
Parasites of 152
Weed killers 144, 308
Weevil :
Apple blossom 111
Strawberry bud .. 264, 283
Wheat :
Baking tests 12, 35
Bunt 293, 305
Cost of production 346
Rust 35, 298, 299, 303
Variety trials .. 52, 53
Yield trials 52
Whey, dried 213
White fly, greenhouse .. 277
White fly parasite .. 127, 277
White rot of onions .. 121, 122
White tip in leeks 142, 295, 304
Willows :
Basket, insect injury .. 280
Cricket bat 80, 81
Disease and pests 18, 81, 275, 280, 296
Lead arsenate, against insect attack 275
Survey of growing industry 345
Variety trials 80
" White " rods 81
Wilt :
Asters.. .. .. 295, 299
Beans 295
Strawberries 75, 121
Tomatoes 129, 137
Wire-worms 281, 282
Wood lice 128
Wool, physiology of growth 190, 203
Woolly aphis :
Immunity, causes 109
Parasite 109, 135
Resistance of rootstocks 102, 109
Worm infestation. (*See* Helminth infestation.)

" Yellow edge " disease of strawberries 98, 99, 105, 111
Yellow stripe in narcissi .. 283

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